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BIOMETRIC SERIES X, XI

A STUDY OF THE LONG BONES OF THE ENGLISH SKELETON

BY
KARL PEARSON, F.R.S. AND JULIA BELL, M.A.

TEXT

PART I. THE FEMUR
CHAPTERS I TO VI - X

2144/13·4·27

CAMBRIDGE UNIVERSITY PRESS
C. F. CLAY, MANAGER
LONDON: FETTER LANE, E.C. 4
ALSO
H. K. LEWIS & CO., LTD., 136, Gower Street, London, W.C. 1
WILLIAM WESLEY & SON, 28, Essex Street, London, W.C. 2
Chicago: University of Chicago Press
Bombay, Calcutta, Madras: Macmillan & Co., Limited
Toronto: J. M. Dent & Sons, Limited
Tokyo: The Maruzen-Kabushiki-Kaisha

1919

To my Friend, Sir GEORGE *D.* THANE, *Professor of Anatomy in the University of London, I dedicate my share in this monograph, not only as a very inadequate acknowledgment of the unceasing help which he has given the collaborators during the twelve years of its preparation but further as a memorial to thirty-five years of sympathetic colleagueship in University College, London.*

K. P.

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161
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PREFATORY NOTE

L' antropologia inglese abdicando, com' ha fatto, nelle mani della facile etnografia descrittiva ha segnato la propria *diminutio capitis*, e non conta più nella scienza.

GIUFFRIDA-RUGGERI, 1905.

IT is very difficult to write a prefatory note to a work which has been as many years in progress as this Monograph on the English Long Bones. It started merely with the intention of illustrating the application of biometric methods to a special field of anthropometric inquiry. But, what was necessary twelve or thirteen years ago—especially in view of Professor Giuffrida-Ruggeri's charges against English Anthropology, perhaps true in 1890, but absolutely false in 1905—has long ceased to be necessary in 1919. Physical Anthropology worthy of the name has adopted biometric methods in the interval, whether we look to our own country and America, or to the continent, notably to Russia, or even to Germany, although there still remain there, as in a less degree in other countries, anthropometricians who believe elementary arithmetic an adequate training for their science. Twelve years is a long period in modern scientific progress and in the course of this work the lines of thought on which it was planned have themselves been developed, and the interests of its cooperators widened and extended until it might be better termed a monograph on the primate long bones. This very development, however, gives the publication an unbalanced character; while it has been possible to determine 80 to 100 characters on one bone of the skeleton of 800 individuals of one primate species, Man, it has of course not been possible to obtain equivalent series for each individual primate species. Our study of primogenial man, and of the lemuroids, lesser apes and anthropoids, has largely depended on what casts and skeletons we could ourselves procure. During the past four years, when this memoir has been passing through the press, the workers of the Biometric Laboratory staff have been occupied much more with national defence than with osteometry. Biometric studies could only be carried on in brief intervals of rest taken from the computation of machine gun-sights for use against low flying airplanes, from the construction of gun charts and high angle range tables for protection against aircraft, or from other problems of like war-urgency. Under such circumstances, when travel was impossible, much that we have desired to do has remained and must remain undone. Again, the sums set apart originally for the publication of this memoir have proved, owing to the enormous increase in cost of production, wholly inadequate to carry out the full scheme. We have been compelled, in opposition to the fundamental principle of this Laboratory, to omit the great bulk of the frequency-distributions and of the correlation tables for the 17th Century London femora. We can only hope that it may be feasible to issue them with a later part of the monograph; but of this we are

not very hopeful for the grant to the Laboratory has been reduced, and its financial future, with the necessary increase in salaries and in printing costs arising from war changes, must mean a much lessened staff and a lessened production, if we fail to obtain further outside appreciation and assistance for our work in the stringent times to come.

The earlier stage of this memoir embraces the first five chapters—these chapters are essentially an illustration of the application of biometric methods to the study of a single long bone. With the remaining Chapter of Part I the transition begins, for as we started to study the individual characters of the human femur, we found ourselves led on to consider not only such characters in other races than the English, but also in the anthropoids and ultimately in a wide range of primates, although we were compelled to limit ourselves to a few specimens of each genus. This transition was completed when the second half of Chapter VI was written, and in Chapters VII to X of Part II the reader will find in the discussion of every individual character the values for each primate genus dealt with. This fuller treatment we think may increase the interest of the whole and emphasise what we feel to be a very important point, namely that the anthropometrician, perhaps realising the great extent as it is of his science, has not invariably chosen for his absolute measurements and indices those which are most suitable and suggestive when applied to the whole range of primates. It may be said that he is concerned only with man. To this the necessary and sufficient reply is that those measurements and indices which are suited to the whole range of primates are much more likely to be of value and suggestive when applied to discriminate racial differences in man than any other measuremental functions. Racial anomalies and even racial differences are signposts to relative stages in human evolution, and this usually signifies that they are closer to or more remote from the lines of development of the lower primates. It is impossible to grasp the evolution of the human femur from palaeolithic to recent man without some appreciation of the characters of the femur in the *Simiadae* and *Simiinae*, and we will venture to add in the *Lemuroidea* also. It is this broad truth which has led to the development of our work on 17th Century London femora into a more detailed study of the primate femur. We have not been the first to realise this necessity: to a lesser extent the need was felt by Bumüller, Klaatsch, Rodriguez, and some of the still earlier French femoralogists.

For the purchase of primate material we have to acknowledge a grant in aid from the Government Grant Committee of the Royal Society. Also a very valuable donation from the former Secretary to the Laboratory, H. Gertrude Jones.

When an investigation has extended over as many years as the present has done it is almost impossible to enumerate all those who have aided us in the course of our labours. Some account of our helpers is given on pp. 2—3, and the dedication of this work stands as a small recognition of the man who has given us chief encouragement from stage to stage. At the same time it is only just to Sir George D. Thane to say that he has never seen a proof, nor have any conclusions drawn from our data been put before him. He is therefore absolutely free from any responsibility for our blunders, of which there are sure to be many, for our opinions, of which some are certain to be proclaimed wrong-headed, or for our terminology, of which we feel quite

certain he will disapprove when he first reads it, but which brevity has compelled us to adopt, although no doubt it might with greater imagination have been better chosen. For assistance not specially acknowledged in the work itself we have in the first place to thank Professor Arthur Keith, F.R.S., who has been most helpful and generous as on former occasions in allowing us to consult the invaluable material in his charge. Our thanks are also due to Professor A. Macalister, F.R.S., for permitting us to re-examine the Naqada skeletons, which had passed from our Laboratory to Cambridge, and for the loan of precious material for photography. Dr W. H. Duckworth and Professor G. Bourne have given much appreciated aid in a variety of ways.

In concluding this prefatory note the senior author wishes to take upon his own shoulders all responsibility for the conclusions and opinions expressed in the work. Upon him has fallen the task of writing the memoir, of photographing the material and of making a very considerable proportion of the more recent measurements, especially those on the lower primates, and those on the patellar surface, the torsion and the fundamental triangle. The contributions of his former colleague and present co-author are especially involved in the London data, their measurement and reduction, and the preparation of the sheets of measurement, and of similar work on a portion of the primates. It undoubtedly involved the more arduous section of the joint work and called for scrupulous accuracy and caution. Aid in the preparation of sections, drawings and diagrams has been given by E. Augusta Jones, and E. Noel Karn, and in calculation of constants for the lower primates by Eleanor Pairman and Mary Seeger, to all of whom the authors' hearty thanks are due. Other sections of the monograph are in a more or less advanced stage of progress, and it is hoped will not be indefinitely delayed.

KARL PEARSON.

DRAPERS' COMPANY BIOMETRIC LABORATORY.
February, 1919.

CONTENTS

		PAGE
	PREFATORY NOTE	iii
	ERRATA	viii
CHAP.		
I.	INTRODUCTORY. CHARACTERS OF THE FEMUR MEASURED AND METHODS OF MEASUREMENT	1
II.	THE SEXING OF THE LONG BONES	40
III.	ON THE CHIEF ANOMALIES OF THE FEMUR	62
IV.	THE TYPE OF THE ENGLISH FEMUR AND ITS COMPARISON WITH THOSE OF OTHER RACES, AND THE INFLUENCE OF SIDE AND SEX	114
	FOLDING TABLES OF MEAN VALUES OF ENGLISH FEMORAL CHARACTERS (WITH PROBABLE ERRORS) AND COMPARISON WITH THOSE OF OTHER RACES. TABLE IV (MALE) AND TABLE V (FEMALE)	*Facing* 128
V.	THE VARIABILITY OF THE ENGLISH FEMUR, ITS COMPARISON WITH THAT OF OTHER RACES, AND OF OTHER BONES, AND THE INFLUENCE OF SIDE AND SEX	161
VI.	THE CORRELATION OF CHARACTERS IN THE ENGLISH FEMUR, ITS COMPARISON WITH THAT OF OTHER RACES AND OTHER BONES, AND THE INFLUENCE OF SIDE AND SEX	192

ERRATA

The reader is earnestly requested before studying this work to make the corrections given below. With the exception of the first two, they all depend on an unfortunate oversight: namely the Oblique-Direct Trochanteric Lengths Index was calculated, and properly calculated on the Oblique Trochanteric and Trochanteric Lengths, but in preparing the Tables the Oblique-Maximum Lengths Index influenced the pen of the writer, who put Oblique-Maximum Trochanteric Lengths Index. He thus preserved the relationship of names, but not the correspondence of the measurements and indices.

p. 116 Table II. Band Radial Index: *For* I_{β_1/β_2} *read* I_{β_2/β_1}.

p. 116 „ „ Secondary Bust Ratio: *For* $I_{t/c}$ *read* $I_{t/a}$.

p. 121 Table III. *For the Index* Troch. Oblique Length/Troch. Max. Length *read* Troch. Oblique Length/Trochanteric Length.

p. 134 Table VII. Male Column: *For* Trochanteric Oblique/Trochanteric Max. *read* Trochanteric Oblique/Trochanteric Length.

p. 134 Table VII. Female Column: *For* Troch. Oblique Length/Troch. Max. Length *read* Troch. Oblique Length/Trochanteric Length.

p. 142 Table IX. Make the same index correction as on p. 134 Table VII twice.

p. 163 Table II. Last line (*nn*): *For* Oblique Max. Trochant. Index | Oblique Trochanteric/Maximum Trochanteric Length *read* Oblique-Direct Trochanteric Index | Oblique Trochanteric/Trochanteric Length.

p. 165 Table IV (*nn*): *For* Oblique-Maximum Trochanteric Index *read* Oblique-Direct Trochanteric Lengths Index.

p. 177 Table VII. *Change in second column* Oblique Maximum Trochanteric Index *to* Oblique-Direct Trochanteric Lengths Index, *and change in seventh column* Oblique Maximum Trochanteric Length *to* Obique-Direct Trochanteric Lengths Index.

p. 181 Table IX. Second Column: *For* Oblique Max. Trochanteric *read* Oblique-Direct Trochanteric Lengths Index *and make the like change in the ninth column.*

p. 194 Table II. Second line of column of Character Pairs: *For* Oblique Trochanteric with Maximum Trochanteric Length *read* Oblique Trochanteric with Trochanteric Length.

p. 206 Table IV. Character Pair 28 in second column: *For* Obl. and Max. Trochanteric Lengths *read* Oblique Trochanteric and Trochanteric Lengths. Character Pair 20 in sixth column: *For* Oblique and Max. Trochanteric Lengths *read* Oblique Trochanteric and Trochanteric Lengths.

A STUDY OF THE LONG BONES OF THE ENGLISH SKELETON

PART I. THE FEMUR

CHAPTER I

THE CHARACTERS RECORDED AND THE METHODS OF MEASUREMENT

(1) *Introductory.* The present study is a much-delayed further instalment of the investigation into the variability and correlation of the long bones started in connection with the Biometric Laboratory in 1895. In that year Professor Flinders Petrie sent from Egypt a large number of skeletons of the prehistoric Naqada population, the late Mr A. B. Pearson-Gee providing the Laboratory with the funds needful for defraying the cost of the material.

In more recent years further Egyptian long bones of definite periods have been provided by Professor Petrie, but at present in hardly sufficient numbers to warrant a detailed investigation for comparative purposes. The original Naqada material was measured by Dr Ernest Warren and his memoir was published in the *Philosophical Transactions*[1]. It was the first paper to approach the subject from the biometric side, and will be cited frequently in this investigation.

The material of the present paper consists of two considerable series of long bones in the Anatomical Department of University College, which were most generously placed at the disposal of the Biometric Laboratory by Professor G. D. Thane for purposes of measurement. These two sets of bones are conveniently described as the "Whitechapel" and "Liverpool Street" or "Moorfields" series. They are for osteological material fairly extensive, and besides the long bones comprise considerable numbers of skulls, which have also been measured in the Laboratory and reported on by the late Dr W. R. Macdonell[2]. In the papers referred to below as full accounts of the date and locality of the Whitechapel and Liverpool Street materials are given as seemed then possible—the bones having escaped investigation *in situ*. There is little to add now to what was then stated. The general conclusions formed by the Director of the Biometric Laboratory from such information as was available may be thus stated:

[1] 1897, "An Investigation of the Variability of the Human Skeleton, with special reference to the Naqada Race...," Bibl. 77.

[2] "A Study of the Variation and Correlation of the Human Skull with special reference to English Crania," *Biometrika*, Vol. III, pp. 191—244, 1904 (Whitechapel Skulls), and "A Second Study of the English Skull with special reference to the Moorfields Crania," *Biometrika*, Vol. V, pp. 86—104, 1906 (Liverpool Street Skulls).

(i) that the Whitechapel material was probably from a plague pit of the seventeenth century; possibly, but very improbably, it might have arisen from a "clearance pit" made for Sheen's Burial Ground (1820—1854). See *Biometrika*, Vol. III, pp. 193—199.

(ii) that the Liverpool Street or Moorfields material was also probably from a seventeenth century plague pit; possibly, but improbably, from a "clearance pit" made for Old Bethlem Burial Ground; the former assumption gives a date of 1665, and the latter any date from 1569 to 1750, when the site was undoubtedly built over. See *Biometrika*, Vol. V, pp. 86—91.

The only objection to dating both series of bones as 1650—1700 plague pit material, lies in the nature of the material itself. The results obtained for the two series are in fair accordance—indeed, so close for the long bones that we have pooled our material. But inspection of both the long bones and the skulls seems to some extent to suggest a difference hardly brought out by the measurements. The Liverpool Street crania (cf. the photographs in the memoirs cited) appear to be of a somewhat more primitive type than the Whitechapel, and this to a certain degree is confirmed by the bones. It is not possible to say whether this may be due to any selective action of the adjacent lunatic asylum, Bedlam, or to influence of the physical environment, to the soil, etc., *post mortem*. It may be partly due to class differences in the populations drawn from. Out of 700 Whitechapel femora syphilitic evidence, severe, slight or doubtful, was found in 33 cases, or not quite five per cent.; out of 217 Liverpool Street femora, syphilitic evidence was found in only one femur—a severe case. In the same way evidence of rachitis, rheumatism and of general pathological conditions was far more copious in the Whitechapel than in the Moorfields material. This may point only to a difference in class or to a real difference in period. It is, for example, probable that syphilis was far more widespread in the reign of Charles II than fifty years earlier. Not too much stress should be laid on pathological differences in the two series, but taken in conjunction with the general appearance of the bones, there is some evidence to suggest that the Moorfields material belongs to a differential and possibly earlier class or group of the English population.

The present study of the long bones is essentially of a cooperative character. A considerable portion of the measurements were originally made by Miss Marion Radford and by Miss Eva Bramley Moore, later some additions on the radii were made by Dr Crewdson Benington, finally further essential measurements on the femora were undertaken by Miss Julia Bell and Mr B. W. Miller. Dr Alice Lee and Miss E. Y. Thomson contributed at certain points. The Director of the Biometric Laboratory designed the measurements taken with a camera, and took the illustrative photographs. He is also responsible for the text of the paper. The most arduous part of the work, however, the reduction of the measurements, was undertaken by Miss Bell, who contributed not only this, but many re-measurements. The Director of the Laboratory is in the main responsible for the examination and discussion of associated literature. To Professor Thane we are indebted not only

for the original generosity, which made the work possible, but for ever ready suggestion and guidance at each stage of the work. We owe him very ample apology for the long period of delay which has accompanied our investigations, but the task has been an extremely heavy one, and the Laboratory has never been in a position to allow one of its members to devote two unbroken years to its completion. To another member of the University College Department of Anatomy we owe also a very great debt, which undoubtedly gives him a position to claim a share in this paper. Dr E. C. Derry until he took up war service was invariably at our disposal in all cases of difficulty. He has sexed the bones for us from anatomical appearance, and he has examined the individual bones for the record of anomalous and pathological states. The question of sexing will be fully discussed below, but the measure of our debt to Dr Derry is summed up in the words that when we were in grave doubt as to the validity of the sexing we had reached, he gave us confidence again in the possibility of sexing[1], and so enabled us to bring the work to a conclusion. His loss to us during the past year when this work was being written has been very great indeed.

(2) *On the Measurements taken.*

The measurements made will be described individually below; the apparatus used included an osteometer of Broca type, an osteometer of Hepburn's model lent by Professor Thane, calipers of various types, a modified Klaatsch cranial contour tracer used for projecting various points of the bone onto a horizontal plane, a torsiometer of our own design, a whole plate photographic camera with Goerz astigmatic lens used for obtaining an image of the head of the bone on a ground-glass drawing plate in the focal plane, a powerful electric lantern for illuminating the bone, and a solid stand with universal joint for supporting the bone in any position, such as is in general use in any physical or chemical laboratory. The photography for this memoir has had to be carried out under very grave difficulties; this must be the excuse for the poor character of much of it[2], which does not reach the standard which we have placed before ourselves; it may, however, suffice to indicate some of the points we need to bring before the reader[3].

The diagrams illustrating the measurements taken were obtained by means of a suggestion of Professor Thane's. Not content with our Laboratory diagrams of

[1] *I.e.* in the general accordance of anatomical and mathematical methods of sexing.

[2] Although the Biometric Laboratory has been in existence for twenty years it has never possessed a photographic room. At present and for the last four years all the photography has had to be done in the space *between two windows* of a lecture room with endless cross and no top light. This is achieved (when the room is not required for lectures or research workers!) by the operator standing on a kitchen table on which the material to be photographed is placed and working a camera with horizontal focal plane on a rough wooden frame, with no fine adjustments, made by a carpenter at a cost of 5*s.* 6*d.*! That this can occur in a college which makes a great profession of assistance to research work is a good illustration of the complete chaos which exists in University matters in London.

[3] Circumstances connected with the war have also markedly lowered the quality of photographic prints and of their half-tone reproductions.

the parts of the femur, he offered to lend us Dr Lawrence's original pencil drawings prepared for Thane's edition of Quain's *Anatomy*, as a basis for our indication of measurements. Messrs Longmans, Green & Co. gave a most ready and kindly consent. Diagrams B, C, D and E were then prepared by photographing Lawrence's drawings and adding on the photographs the necessary lines and planes, the whole being then reproduced by half-tone process. Unfortunately Lawrence's drawing of the anterior face of the whole femur was rather too faint for reproduction in this manner, and a new drawing, based on Lawrence, had to be made; this was kindly provided by Miss Margaret Dalgliesh, and forms Diagram A: see Plates I—III, Atlas.

(3) *Measurements of the Femur.* Primary Lengths.

(*a*) *Maximum Length* from top of head to bottom of internal condyle (M.L., see Diagram A, Plate I). The points between which this length is measured are not the points of contact of the vertical planes of the osteometer when the bone is in the oblique position.

Taken either with the calipers, or with the osteometer swinging the bone round with the internal condyle on the fixed vertical plane until the moveable vertical plane, always in contact with the head, is at its maximum distance; if the posterior surface of the bone as usual faces the base-board of the osteometer, it may be needful to elevate the proximal end of the bone slightly from the base-board to obtain in this way the maximum length.

(*b*) *Trochanteric Length.* From top of great trochanter to bottom of *external* condyle[1] (T.L., see Diagram A, Plate I). Taken with the calipers.

(*c*) *Maximum Trochanteric Length.* From top of great trochanter to most distant point on bottom of *internal* condyle (M.T.L., see Diagram A, Plate I). This is the measurement taken by Turner[2]. It is also used by Koganei[3] and Mollison[4]. We cannot find what Martin's trochanteric length was[5], but suspect it to be the maximum trochanteric length. Klaatsch recommends for trochanteric length our (*b*), *i.e.* from top of *trochanter major* "bis zum distal vorragenden Punkte des *condylus externus*[6]."

Lehmann-Nitsche measures what he terms the *Trochanterlänge* and describes it thus: "Messplatte Abtasten des am meisten vorspringenden Punktes...des Trochanter major mit dem Winkelmass[7]." We do not feel clear as to what he has really measured, and this obscurity seems to us involved in many authors' treatments of femoral measurements. There is thus great difficulty in any comparison of measurements.

(*d*) *Oblique Length.* So called by English writers; it is more lucid but less brief to term it with the French anthropologists "length in oblique position." They again in their turn occasionally sin by measuring solely this oblique length, and often merely speaking of it as the "femoral length"; only some slight allusion

[1] The external condyle is selected partly because the resulting length then corresponds most closely with what is obtainable in the living.

[2] Bibl. 42. [3] Bibl. 64. [4] Bibl. 100, p. 588.

[5] Bibl. 63. [6] Bibl. 87, S. 610. [7] Bibl. 69, S. 283.

to the method of measurement may then show the reader what has actually been recorded. This is the vertical projection of the bone (O. L., see Diagram A, Plate I), and is taken on the osteometer with anterior face upwards, the condyles in contact with the fixed vertical board and the moveable vertical board brought into contact with the head.

(*a bis*) and (*b bis*) *Stature.* Found by Pearson's Reconstruction Formulae.

Anatomists and anthropologists have laid great stress on the oblique length of the femur, asserting that as a component part of stature it must be of more importance than the maximum length in determining stature. The fallacy of this view is its neglect of the whole conception of correlation ; thus the male humerus is correlated more closely with stature than the tibia is, but the tibia is a component part of stature and the humerus is not[1]. Parsons writes as follows in 1914[2]:

"It has been said that from the maximal length Pearson deduces the average stature of the series. I am not quite clear why he chooses the maximal in preference to the oblique length, since the latter is the one which really forms a fraction of the body height; but as I have not the mathematical knowledge to adapt his work to the oblique length, I am only too glad to avail myself of it as it stands."

It is suggestive of the accuracy with which Parsons has studied the memoir to which he refers that the equations for determining the stature from oblique length for both sexes are actually given alongside of those for the maximum length on p. 184 of the memoir in question[3], and immediately above a passage from which Parsons extracts numerical constants. Further, on the previous page it has been shown that the following correlations hold:

	Male	Female
Stature and Maximum Length	·8105	·8048
Stature and Oblique Length	·8025	·8007

In other words, stature is less closely associated with oblique than with maximum length, and accordingly the latter, and not the former, is the right measurement to use for the reconstruction of the stature[4].

It is of interest to place here the formulae for reconstructing stature from the maximum and oblique femoral lengths. If S be *living stature* and F_m maximum length, F_o oblique length of dry bone[5], then

Male	Female
$S = 81{\cdot}306 + 1{\cdot}880\, F_m$,	$S = 72{\cdot}844 + 1{\cdot}945\, F_m$,
$S = 81{\cdot}232 + 1{\cdot}894\, F_o$,	$S = 71{\cdot}811 + 1{\cdot}979\, F_o$.

[1] Pearson, Bibl. 79, p. 180. [2] Bibl. 111, p. 243. [3] Bibl. 79.

[4] Pearson had also in mind the convenience of field workers, who can carry osteometric calipers more readily than an osteometer of the Hepburn type. The Broca type is not only far less exact, but is frequently badly made.

[5] We give for S in terms of F_o Pearson's equations of p. 184 (Bibl. 79) with the corrections for corpse length, cartilage and animal matter of pp. 187, 193 and 194 allowed for.

Now we have the following R values in cms.:

	Male		Female	
	F_m	F_o	F_m	F_o
Parsons' Rothwell Data.....	456	453	416	415
Our London Data	446·77	444·35	410·11	406·43

We use the R-femora values because Pearson's formulae are stated to be calculated for the *right* side, otherwise the correction referred to by him on p. 197 might be used. We find the following statures in cms.:

		Male	Female
Parsons' Rothwell Data:	From F_m	167·0	153·8
„ „ „	From F_o	167·0	153·9
Our London Data:	From F_m	165·3	152·6
„ „	From F_o	165·4	152·2

It will be seen at once that for all practical purposes Pearson's reconstructions lead to precisely the same results from both oblique and maximum lengths.

Parsons, professing to use Pearson's reconstructions, gives ♂ 167 cms. and ♀ 160 cms. It does not seem to have struck him that this corresponded to a sex ratio of 1·043, which is only known to occur among dwarf races, *e.g.* Bushmen or Aigtas of Luzon. He was, so to speak, combining into one race the neolithic males of Great Britain and the women of Flamborough Head, the tallest race of this country! On investigation it will be found that his value is 6 cms. too large[1]. By comparison with Pearson's Tables (*loc. cit.* p. 243) it will be seen that Parsons' Rothwell femora give a racial stature corresponding almost exactly with that of neolithic man in Britain, while our seventeenth century Londoners correspond closely with Romano-Gauls in stature. Rothwell exceeds London by 1·7 cms. for the male and 1·1 cms. for the female, but both appear to be far below the English commonalty of to-day which is given by Galton as 170 cms. for males and 158 cms. for females. This confirms the view that stature has not yet received sufficient scientific attention in this country. Our seventeenth century Londoners were distinctly shorter than the nineteenth century London commonalty. Parsons could throw light on the matter if he would measure the modern rural population of Rothwell, which, if his view be correct, *i.e.* that the Rothwell femora are mediaeval English, should be in bulk descended from the population he has measured. Does migration, nutrition or natural selection account for the differences we find in London English?

[1] He has apparently read his values off a graph in Pearson's paper which applies only to *males*, and was introduced to show the change in relationship between stature and femur etc., when the range is taken to include *male* giants and dwarfs.

(*e*) *Trochanteric Oblique Length.* This is the vertical distance from the top of the great trochanter to the infra-condylar plane (T. O. L., see Diagram A, Plate I).

In this measurement the bone being placed on the base-board of the osteometer with the two condyles both in contact with the fixed vertical board, the face of a cube of known edge is brought into contact with the sliding vertical board, and the parallel face into contact with the top of the great trochanter. The magnitude of the known edge of the cube, say 4 cms., must be subtracted from the osteometer reading. It is convenient to attach a block of this kind to one side of the sliding vertical board of the osteometer.

Diameters of Head.

(*f*) *Greatest Diameter of Head in Vertical Plane.* This is the greatest diameter of head parallel to the base-board, when the bone is placed in the oblique position resting on the osteometer and is taken with the small calipers (V. D. H., see Diagrams A and B, Plates I and II).

(*g*) *Greatest Diameter of Head in Horizontal Plane.* This is the maximum diameter of head perpendicular to the base-board when the bone is in the same position, taken with the small calipers (H. D. H.).

It is desirable to mark the terminals of (*f*) and (*g*) on the head before final measurement.

Diameters of Infra-Trochanteric Region.

(*h*) *Minimum antero-posterior Diameter.* The least antero-posterior diameter in this region, avoiding the gluteal ridge by placing the point of the calipers on its inner side (PL. A. P. D., see Diagrams A and B, Plates I and II).

(*i*) *Transverse Diameter.* At the same level[1]; this is usually about the spot where the vertical plane through the middle of the small trochanter meets the spiral line and is taken with the small calipers at right angles to the antero-posterior diameter (PL. T. D., see Diagrams A and B, Plates I and II).

(*j*) *Manouvrier's Platymeric Index* = 100 PL. A. P. D./PL. T. D. (Plate I).

A good deal of discussion has taken place with regard to so-called "transverse platymery." The name and idea were introduced by Manouvrier[2], to cover cases in which the antero-posterior diameter was larger than the transverse diameter in the platymeric region. Such cases occur, but are occasionally accompanied

[1] "In obtaining the data for the Platymeric Index Professor Manouvrier suggests that the *smallest* antero-posterior diameter be taken first; and at the level where this is found that the transverse diameter be then measured. The point at which the smallest antero-posterior diameter is situated varies slightly in its distance below the small trochanter in each bone. Professor Halliday Scott of Otago University measures this diameter at the level where the spiral line crosses below the descending root of the small trochanter; but as this does not in every case correspond with the smallest antero-posterior measurement, I have followed the method suggested by Professor Manouvrier." Hepburn, Bibl. 71, p. 122. This is also our rule. Unfortunately Warren, although he refers to platymery, does not determine the index in the long series of Naqada femora he deals with. Bibl. 77, p. 144.

[2] Bibl. 48 and 57.

by much bowing and marked development of the pilaster, even in some instances with marked convex popliteal surfaces. Good illustrations are provided in the sections reproduced below of the Egyptian femora B. 111, R. and L., kindly loaned to us by Professor A. Macalister of Cambridge: see Plate XXVIII. Bones such

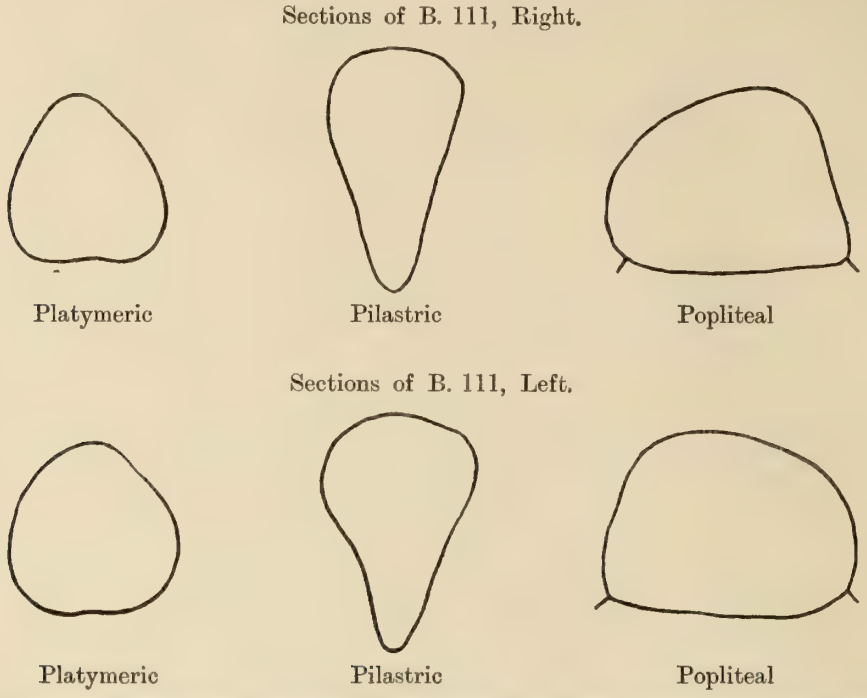


Fig. 1. To illustrate "transverse platymery" (stenomery), and associated pilastric and popliteal forms.

as these are of course rare, and may be described as abnormal. It may be doubted, however, whether the name "transverse platymery" and Manouvrier's account of its origin can be unreservedly accepted. The frequency distributions of the platymeric index do not show marked signs of heterogeneity at the high index end, nor do such signs appear in the correlation tables of this index with other characters. It seems doubtful whether there are special causes at work producing "transverse platymery," although marked cases of it may occur in diseased bones. Manouvrier classifies by this index as follows:

Under 80, sagittal platymery; 80 to 100, absence of platymery; over 100, transverse platymery.

Lehmann-Nitsche[1] proposes to call these three groups, the *platymeric*, the *eurymeric* and the *stenomeric*. Bumüller[2] suggests extending the platymeric range from 80 to 85, as he considers that femora from 80 to 85 exhibit a typically developed form of platymery, and that it would be arbitrary to exclude them from the platymeric group. It seems to us that there must always be something arbitrary about such classifications, and that the division is merely utilitarian, the change in index being perfectly continuous; it should therefore be taken where it

[1] Bibl. 69, p. 223.

[2] Bibl. 81, p. 45.

is most convenient for classificatory purposes, either individual or racial. As 85 leads to more than 50 °/₀ of individuals and races falling into the platymeric group, it appears better to retain Manouvrier's original divisions. It is convenient, however, to follow Lehmann-Nitsche and replace by simple "platymeric" and "stenomeric" the "sagittal platymeric" and "transverse platymeric" terminology of Manouvrier. See Plates VI, VII, and XXXIII—XXXV.

Diameters of Middle or Pilastric Region of Shaft.

(*k*) *Maximum Antero-posterior Diameter.* The greatest value of this diameter must be found wherever it occurs on the *linea aspera* (on the "pilastre" of Broca); it is usually at its highest point, but this is not always the middle of the shaft. Taken with the small calipers (*Pil. A. P.*, see Diagram A, Plate I).

(*l*) *Transverse Diameter* at the same level as (*k*) wherever (*k*) falls, taken with the small calipers (*Pil. Trans.*). We found it convenient to place the bone anterior face upwards on a horizontal plane; (*k*) was then measured vertically and (*l*) horizontally. These are really projections of the chief diameters, which are not necessarily at right angles to each other, although nearly so.

(*m*) *Pilastric Index* = 100 *Pil. A. P./Pil. Trans.* (*Pil. I.*).

Popliteal Measurements.

(*n*) *Popliteal Length.* From apex of popliteal surface to centre of intercondylar line, i.e. the line which forms upper limit of intercondylar fossa. Taken off with the dividers and read on scale (*Pop. L.*, see Diagram A, Plate I).

The popliteal apex requires some care in its determination. Klaatsch[1] holds that it cannot be accurately appreciated and would discard popliteal length. Hepburn measures the popliteal length "from the posterior aspect of the external condyle upwards to the point at which it could be definitely determined that the margins of the *linea aspera* were diverging from each other. Of necessity this upper point is far from being precise, although the amount of error can never be so great as to invalidate the value of the measurement[2]." We think with a little practice the same observer will reach practically the same point on a second determination; we are less certain as to the comparative value of the measurements taken by different observers. We should certainly not go as far as Klaatsch and abandon the measurement entirely.

(*o*) *Popliteal Width.* Taken at 4 cms. above highest point of patellar articular surface in front of external condyle (*Pop. W.*, see Diagram C, Plate II). The constant distance of 4 cms. was suggested by Manouvrier, although he considered that it was allowable to slightly modify this distance in the case of long or short femora. Klaatsch[3] has discarded the 4 cms. and proposed to replace it by 2 cms. and has defended this change on the ground that measurements taken at 2 cms. would show far greater differences in *Pithecanthropus erectus*, the Neanderthal femora and modern

[1] Bibl. 87, S. 612. [2] Bibl. 71, p. 123. [3] Bibl. 87, S. 654.

femora than at 4 cms. The contours below, drawn after Klaatsch[1], are apparently the basis of his statement, but do not seem to us to demonstrate adequately his standpoint.

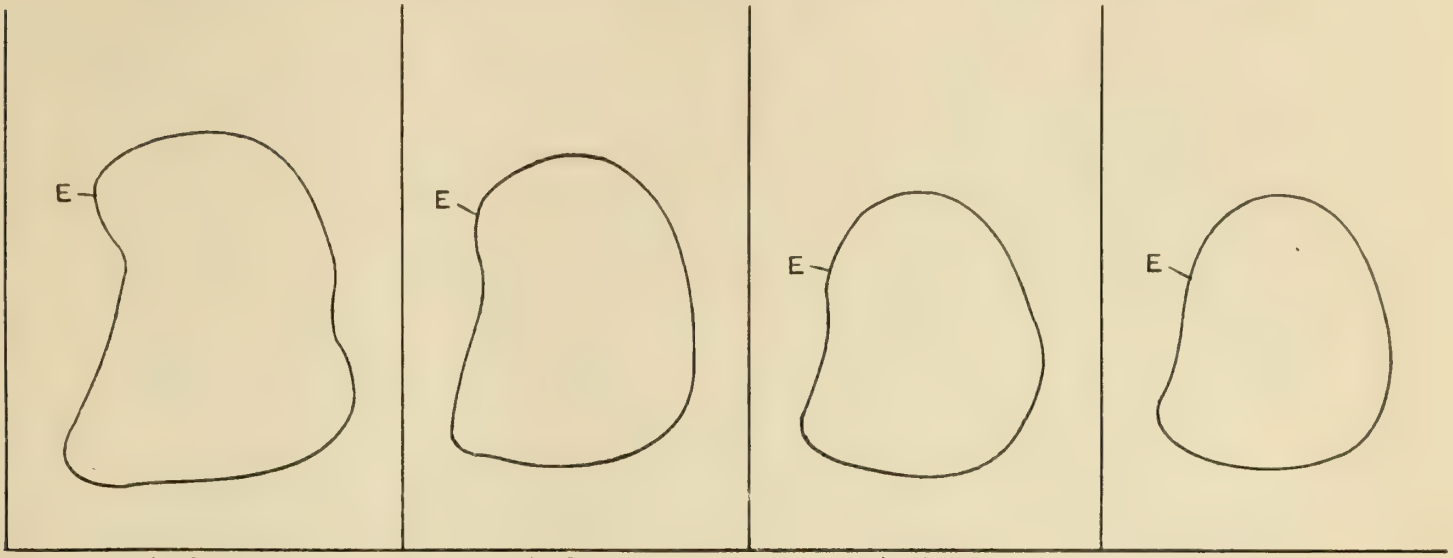
Pithecanthropus: dotted line. *Neanderthal:* continuous line.
Recent human femur of same length: broken line.

FIG. 2. Diagram of contours of Distal Epiphyses, after Klaatsch.

It appears to be entirely a question of what index is taken to represent the peculiarity Klaatsch wishes to emphasise. In Plate XXXII we have four femora of which W. 85 shows the usual type of popliteal area, the spread-out towards the condyles starting at the popliteal apex; W. 285 and W. 104 are bones in which the shaft continues cylindrical right down towards the distal end, and in this they resemble the Neanderthal femora. W. 121 is a similar, but not quite so marked case. Now the popliteal index at 4 cms. might or might not differentiate between these bones, but we are not certain that taken at 2 cms. it would. We are inclined to think an index formed by the ratio of the popliteal transverse diameter to (i) the bicondylar width, or (ii) the popliteal length, or (iii) the pilastric transverse diameter might bring out the cylindrical character of the shaft rather better than an index based on the transverse diameter at 2 cms. Such indices are recorded in our tables of measurement.

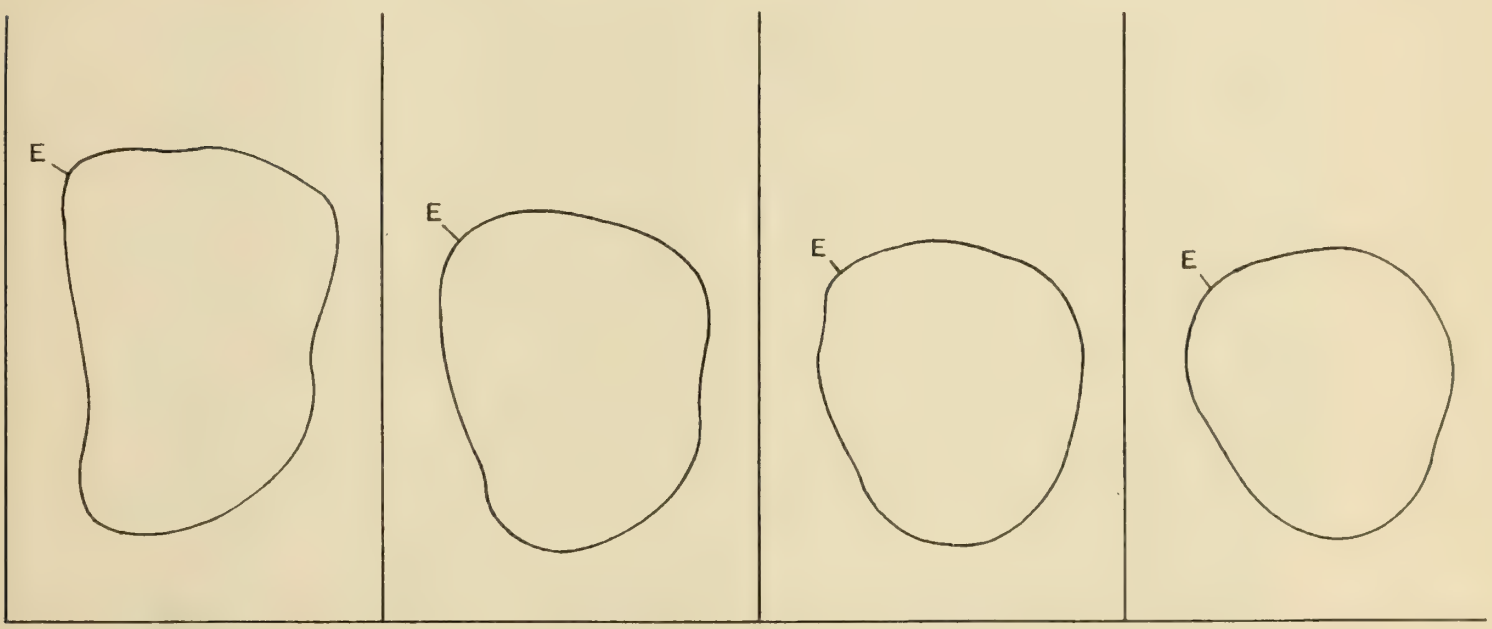
[1] *Loc. cit.* S. 662. Since this paper went to press the death of Klaatsch has been announced. We deeply regret the loss of a suggestive worker, if his temperament did not lack the certitude and aggressiveness of certain elements of modern German science.

Again consider Figs. 3 and 4. Here we have popliteal sections drawn perpendicular to the standard vertical plane[1] at 2, 3, 4 and 5 cms. of the femur W. 593



Sections of W. 593. *E* is the external supra-condylar ridge. The vertical is the trace of the standard vertical plane on the plane of section which is taken parallel to the standard horizontal plane.

FIG. 3. Popliteal Sections. Usual type. (Actual size.)



Sections of L. S. 46. *E* is the external supra-condylar ridge. The vertical is the trace of the standard vertical plane on the plane of section which is taken parallel to the standard horizontal plane.

FIG. 4. Popliteal Sections. Convex (*Pithecanthropus*) type. (Actual size.)

[1] *I.e.* the plane of the base-board of the osteometer, when the bone with anterior face upwards is placed upon it.

which is of the usual concave type, and femur L. S. 46 which is of the convex or *Pithecanthropus* type of popliteal area. Now several points occur here: (i) at 2 cms. both femora are *concave* in the popliteal area, (ii) for W. 593 and L. S. 46 the sections at 2 cms. are both concave also on the anterior face, and this is still manifest in L. S. 46 at 3 cms. This might be a source of confusion, if the antero-posterior diameter were taken at 2 cms. We think that for most bones Manouvrier's 4 cms. was a thoroughly suitable position and we have accordingly maintained that value for *all* bones, notwithstanding Klaatsch's rejection of it.

(*p*) *Direct Antero-posterior Diameter.* The bone resting in the usual position on both condyles with the anterior surface upwards the highest point *m*, on the vertical plane through the popliteal width was determined and marked, and the distance of this from the midpoint *p* of the popliteal surface, *i.e.* the point equidistant from the two supra-condylar ridges in the same plane, was measured (*mp.*, see Diagram B, Plate II).

As a rule the line *mp* thus determined will be only roughly perpendicular to the transverse popliteal diameter or the popliteal width. This width we take parallel to the other standard vertical plane transverse diameters, *i.e.* horizontally when the bone is in the standard position on a horizontal plane. Again, it will be more or less parallel to the popliteal surface at the point *p*. Of course, taking any transverse diameter as we do on the bone in its standard position we are truly measuring the projection of a maximum transverse diameter on the standard vertical plane[1], but we hold that definiteness and uniformity can only be obtained in this manner[2]. Accepting this method of obtaining the transverse diameter, we believe that it would be better on the whole to take *mp* perpendicular to the transverse diameter, *i.e.* perpendicular to the standard vertical plane. This will be approximately, but by no means universally, perpendicular to the popliteal surface. When it is perpendicular (see Diagram E, Plate III) then *mp* thus found is very close to the *mp* of Manouvrier's measurement. Thus on the scale of Diagram E Manouvrier's *p* is about 2·5 to 3 mm. above the *p* of the diagram, and the distance of *m* to the two *p*'s is sensibly the same. There is not much difference in the case of the sections at 4 cms. of our Figs. 3 and 4. If, however, the popliteal surface be greatly inclined to the standard vertical plane, then *mp* as determined by Manouvrier's method will as a rule be more nearly perpendicular to the popliteal surface than *mp* drawn perpendicular to the standard vertical plane, but it may in this case make an angle far from right with the transverse diameter or popliteal width[3].

[1] We have made an exception of the cases of foetal and non-adult bones, where we have taken *one-tenth* the diaphysial length—a rule we should like to see extended to adult bones.

[2] If we simply define the transverse diameter as the maximum diameter of the cross-section, such a diameter will in certain cross-sections pass through the external supra-condylar ridge, and occasionally there will be two transverse diameters equal in length, but very different in position.

[3] Assuming Hepburn's diagrams (Bibl. 71, p. 140) to be all properly orientated to the standard vertical, then his popliteal section Fig. 9 of a modern British femur is a case in point for the vertical *mp* would be some 1 mm. longer than his *mp*. Hepburn, however, does not clearly define his point *m*; he speaks of it as "the most projecting point on the front of the shaft, at a distance 4 cm. above the

An alternative construction would be to draw the chord joining the points in which the popliteal cross-sections at 4 cms. cuts the internal and external supra-condylar ridges and drop from *m* the perpendicular on this chord; where this perpendicular meets the popliteal surface would be taken as the point *p*. This method, however, involves the laborious adjustment of the bones and the actual tracing of the cross-section in each. It would, nevertheless, give a proper measure of the popliteal curvature, and determine that approach to convexity, which is the characteristic of gorilla and chimpanzee as distinguished from the concave state asserted for modern man. Another alternative would be to measure from *m* to the *nearest* point of the popliteal surface; this would answer well in the case of concavity, but becomes idle when the popliteal surface was convex. We have under the circumstances done our best to follow Manouvrier's rule of the midpoint between the supra-condylar ridges, for, although we are not satisfied with it, we have not hit on a better, equally rapid. We reserve, however, the problem, and propose to devote an independent paper to the form of the femur in the popliteal region, for we are not content to dismiss popliteal diameters as of no importance as Klaatsch has done.

(*q*) *Oblique Antero-posterior Diameter.* From the same point *m* on the anterior surface to the point *n* on the external supra-condylar ridge in the same cross-section through the transverse diameter (*mn*, see Diagrams C and E, Plates II and III).

(*r*) *Popliteal Index* $= 100 mp/Pop.\ W.$ (*Pop. I.*).

The measurement of the direct and oblique antero-posterior diameters of the popliteal region was introduced by Manouvrier in a remarkable paper of 1895[1], being his second study of the *Pithecanthropus erectus*. Manouvrier finds nothing in the upper three-quarters of the bone to differentiate it from a human femur[2]. The trochanteric crest can be parallelled from human femora; the pilastric index differs from those of the anthropoids and equals that of men without being as high as that of many men; it witnesses "péremptoirement l'attitude bipède[3]." The popliteal region is the region in which the Trinil femur is differentiated from the human. With the apes the popliteal region is usually convex, with man it has been said, without much quantitative warrant, to be concave; in *Pithecanthropus erectus* the region is convex. Manouvrier accordingly seeks for a measure of this difference, and finds it in what we have termed above the direct and oblique antero-posterior diameters of the popliteal region, *mp* and *mn*[4]. In the next place Manouvrier seeks for femora in which *mp* is greater than *mn*, and apparently considers that such femora will have a convex popliteal surface. That convex femora can occur in

superior articular border of the external condyle" (*loc. cit.* p. 120). But "the most projecting point" might be different according as to whether it were judged from the standard vertical plane or the popliteal surface.

[1] Bibl. 68, pp. 558—580 deal with the femur. [2] *Loc. cit.* p. 560. [3] *Loc. cit.* p. 560.

[4] "Ces deux diamètres antéropostérieurs *mn* et *mp* doivent partir, en avant, du point *m* qui est extrême par rapport au plan médian et qui occupe la portion la plus renflée de la région" (*loc. cit.* p. 564). This seems to leave the position of *m* as indefinite as Hepburn's "most projecting point on front of shaft." There must be some orientation as by the standard vertical plane.

which *mn* is much greater than *mp* is shown purposely in our Diagram C, Plate II. In Fig. 4, p. 11, L. S. 46 presents a femur of the Trinil type in which *mn* is also considerably greater than *mp*. This is also true in the case of the popliteal sections of gorilla and chimpanzee provided by Hepburn[1]. Dubois, the discoverer of the Trinil femur, who regards it as human-like but not the femur of a man, lays stress on the convexity of the popliteal region and writes in 1898[2]:

"*One* of the differentiating characters I could never find in human femora even separately. I mean the small development of the popliteal space, which is in a high degree convex, because in the midst of it and separated from the lips of the *linea aspera* extends a kind of swelling until near the lower extremity, which is the reason that the lower part of the shaft of the femur has such a round section."

This description agrees extraordinarily closely with the nature of the popliteal region in our femur L. S. 46. If the reader will carefully examine Plate XXXI, (a lens will be useful) he will see in L. S. 46, and to a less extent in L. S. 43, convex popliteal regions placed in juxtaposition with W. 85 with a concave region.

Popliteal surface, showing convexity.

Fig. 5. Section of Q. 229 at 4 mm.

Of course, L. S. 46 is a very anomalous case[3], but many grades of convexity occur. Manouvrier gives five such femora with $mp > mn$, but none of these have a popliteal index at all comparable with *Pithecanthropus erectus*. In three other cases he found a voluminous exostosis in the centre of the popliteal region which accounted for the rounding. Only in one abnormal femur with a completely deformed head eburnated by friction in the acetabulum is $mp > mn$ and a popliteal index exists comparable with that of the Trinil femur.

Hepburn, following Manouvrier and writing in 1897[4], gives 25 cases in which *mp* was $> mn$, although he does not demonstrate that all these sections are convex. A little consideration of Manouvrier's figure[5] for the flattened type of femur with large popliteal area will show that it is possible for *mp* determined by Manouvrier's rule to be $> mn$, and yet the popliteal region concave. See our Fig. 6, p. 15. Thus the index $100\,mp/mn$, while suggestive, is not conclusive for convexity.

[1] Bibl. 71, p. 140.

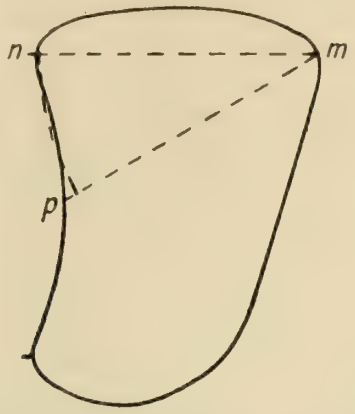
[2] Bibl. 78, p. 8.

[3] Another illustration is that of the Egyptian (Naqada) bone Q. 229 in Fig. 5 here exhibited.

[4] Bibl. 72, p. 6.

[5] Bibl. 68, p. 562.

Unfortunately neither Manouvrier nor Hepburn, as far as we can see, appears to provide the actual value of *mn* for the Trinil femur, although both state that



Case of concave section with $mp > mn$.

Fig. 6. Manouvrier's direct and oblique popliteal transverse diameters.

mp is $>mn$. Neither Hepburn nor Manouvrier were able to refer to the popliteal area in *Homo mousteriensis* (*Hauseri*). We give below a picture of the cross-section. There is no doubt that it is (at 4 cms.) convex without question of pathological origin. It shows, however, nothing of the rotundity exhibited by the other cases of convex popliteal area, its popliteal index being only 69·9, a value below the modern human

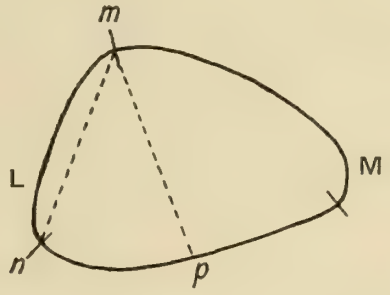


Fig. 7. *Homo mousteriensis* (*Hauseri*) (L). Popliteal (4 cms.) section, convex popliteal surface.

mean, but by no means outside its range. The table we give on p. 16 indicates the main points of comparison.

Hepburn considers convexity so common that it may rank as a human character, and that accordingly this feature does not disqualify the Trinil femur for being considered human, indeed Hepburn argues that this femur is a human femur. But it will be noted that with the exception of four British femora in which *mp* is greater than *mn*, and which are disqualified by their popliteal indices from the comparison, Hepburn's series of "convex" femora consist of more or less primitive races, which also are incomparable with the Trinil femur owing to their

Femur	*Pop. W.*	*mp*	*mn*	*Pop. I.*	100 *mp/mn*
Trinil	33[1]	32[1]	?	97·0[2]	?
Manouvrier's Mediaeval Parisian	32	31	30	96·9	106·7
Hepburn's Swan Hill Australian	33	32	30	97·0[2]	111·0
Hepburn's Rachitic Femur ...	32	31	27	96·9[2]	118·5
Our L. S. 46[3]	40·2	34·8	34·0	86·6	102·3
Homo mousteriensis (Hauseri)[3]	41·5	29·0	26·5	69·9	109·4

popliteal indices[4]. The really comparable femur is the Swan Hill Australian. Manouvrier's Mediaeval Parisian is, as we have noted, pathological. Hepburn's Rachitic Femur had an inflammatory thickening in the popliteal region, and was probably introduced by him because the Trinil femur has large exostoses[5] below the lesser trochanter, and this pathological feature may, it is said, have modified the growth even of the distal third. Manouvrier holds that the "apophyse assez saillante située sur le bord supérieur et extrême du condyle externe vers l'insertion du muscle jumeau extrême" is not pathological, and is an anomaly up to the present unrecognised or very rare in the human race[6]. It seems to correspond in its description to the case of our L. S. 46, and if such apophyses are determined to be pathological, then very little is left to differentiate the Trinil from a human femur. While both gorilla and chimpanzee show marked convexity of the popliteal surface, only in the latter case is *mp* greater than *mn*; the gorilla also has a very low (51—52) and the chimpanzee a human valued (75—79) popliteal index[7], so that

[1] These are the values given by Manouvrier, and Hepburn appears to follow him. Presumably they were measured on the original. By measurement on the photographs, allowing for scale changes we find *Popliteal Width* = 35, *mp* = 28·8 (?), giving *Popliteal Index* = 80·0. Bumüller gives 78·4 as the result of his measurements on the photographs. We feel bound to follow Manouvrier who, we take it, had the actual measurements.

[2] These indices appear to be wrongly calculated by Hepburn, *loc. cit.* pp. 9 and 14.

[3] Taken from the drawing of the popliteal cross-section and this seems the more accurate method, although the absolute measurements on the figure p. 11 will not be the same as those of the calipers, because, however emphasised the instructions, the blockmaker usually fails to get exactly the same size in reproduction.

[4] 1 Lapp, 1 Eskimo, 1 Maori, 3 Negroes, 2 Bushmen, 4 Andamans, 4 Aboriginal Australians and 2 Guanches. The series is completed by two "Hindus" whom it would be impossible without further information to allocate racially.

[5] Manouvrier (and apparently Turner) had supposed these anomalous excrescences to be the "résultant de l'ossification des aponévroses d'insertion de plusieurs muscles fessiers," but he bowed to the decision of Virchow namely that they were true exostoses. Bibl. 68, pp. 558—9. [6] Bibl. 68, p. 559.

[7] Cf. Hepburn, Bibl. 71, pp. 140 and 153. Bumüller (Bibl. 81, p. 111) gives for the popliteal index: Gorilla, 55·1 and 62·5; Chimpanzee, 63·9; Orang, 57·1 and 66·0; Gibbon, *Hylobates syndactylus* 80·8, *H. lar* 95·0, *H. concolor* 76·5; and for the Eppelsheimer Femur, 65·4. The only one of these approaching the *Pithecanthropus erectus* in value is the *Hylobates lar.*

the Trinil femur can hardly be said to have the same type of popliteal cross-section as the anthropoid apes; the resemblance lies merely in the presence of convexity, but this occurs with human femora. It seems to us that further comparison of the Swan Hill Australian, our femur L. S. 46 and the Trinil femur is desirable. If our femur be pathological, is the Trinil femur also pathological, and if so are we to accept Manouvrier's view[1] that another individual of the species might not show the same convex popliteal surface? With the exception of *Hylobates lar* no ape approaches *Pithecanthropus* as nearly as man does in popliteal index. While we should follow Manouvrier in suspense of judgment, and while Hepburn terms the Trinil femur human on the basis of the popliteal form, Klaatsch appears to have no hesitation in asserting that *Pithecanthropus erectus* is pithecoid and not human from the evidence of the distal end[2]. This conclusion he reaches on the difference in length between the external and internal condyles. He shows that in 27 European femora the difference, length of external minus length of internal condyle, is in mm. +·7; for the Neanderthal femora: R. +3, L. +5, for Spy I, R. +5, for a Gilbert Islander +2, a Malay +1, a Javanese +3, and a Negrito zero. For three gorillas, however, −8, −16 and −15, for two chimpanzees −11 and −3 (young), and for *H. syndactylus* −4. But the range among his 27 Europeans is actually +3 to −3, and is extended from +8 to −8 when a large series of bones is measured. If *Pithecanthropus* has a longer internal than external condyle—the actual difference in length has, as far as we can find, never been stated—it would require much stronger evidence than this to demonstrate that it is pithecoid and not human[3].

It seems to us that the popliteal measurements set going by Manouvrier do show as a whole some differentiation both from man and from the anthropoid apes in the Trinil femur. How great the difference we can only tell, when we know: (i) whether femora like the Swan Hill Australian and our L. S. 46 are really pathological, and (ii) whether or not the Trinil femur itself is pathological.

Meanwhile we think the popliteal measurements should not only be continued but be extended by osteometricians.

(*s*) *Maximum Bicondylar Width.* Taken parallel to the infra-condylar plane,

[1] Bibl. 68, p. 580.

[2] Bibl. 87, S. 652—663. Bumüller concludes that the Trinil femur belonged to a gibbon, but fails to explain how a gigantic gibbon of apparently erect posture could have lead a gibbon's arboreal life. Bibl. 81, p. 138.

[3] We may remark here that a good series of measurements on the Trinil femur ought to be published. Most of the measurements (like our own) are taken from the photographs in Dubois' memoir (Bibl. 67 *bis*). But the most straightforward of these do not seem to agree with the one or two actual lengths given by Dubois himself. Hence either his values are only approximations, or the scales of reduction stated for his photographs are not exact ones. Bumüller appears also to have noted this incompatibility. Bumüller (Bibl. 81, Table facing S. 112) gives for the Trinil condylar lengths index (*i.e.* 100 length of external condyle/length of internal condyle) the vague value 91—94, but does not, we think, state how he obtained it. This would give something like −5 mm. for difference of lengths, an improbable, but not impossible, value for man. It did not seem to us feasible to obtain any accurate condyle length measurements on Dubois' photographs.

i.e. with bar of calipers touching lowest points of both condyles in the infra-condylar plane, and the arms of the caliper touching respectively the internal condyle internally and the external condyle externally at a maximum distance (B. W., see Diagrams C and D). This measurement we consider of much importance, especially for sexual and racial differentiation, unfortunately the outer faces of the two condyles are frequently damaged, so that the measurement is impossible or doubtful. The extent to which doubtful measurements should be included is a matter for grave consideration.

We now come to certain measurements on the condyles themselves. The easiest of these to take is:

(σ_1') *Projected Length or Height of External Condyle.* It is the height of the highest point of the external condyle above the standard vertical plane, when the bone is in the standard position on a horizontal plane (see Diagram D, Plate III). It was measured with the point of a scribe-awl which was then brought against a vertical scale with its zero on the base-board. The "height" of the external condyle does not differ much from:

(σ_1) *Natural or Maximum Length of External Condyle.* This is taken with the small calipers from the highest anterior to the lowest posterior point of the external condyle, "highest" and "lowest" signifying relation to the standard vertical plane considered as the base-board of the osteometer. This measurement should be invariably less than (σ_1'), but the two lengths are so nearly equal that with damaged specimens and the possible errors of reading (σ_1') may be in a few cases given as slightly more than (σ_1).

(σ_2) *Natural or Maximum Length of Internal Condyle.* Taken as in the case of (σ_1) the *Projected Length or Height of Internal Condyle* (σ_2') would be easier to take and more satisfactory as far as accuracy of measurement is concerned (see Diagram D, Plate III). But its anatomical value is more doubtful. For, while, when the femur is placed on the horizontal plane, anterior face uppermost, the summit of the external condyle is approximately vertically above its point of contact with the standard vertical plane (Diagram D), the summit of the internal condyle may be almost above the intercondylar notch, and thus the natural length differs or may differ widely from the projected length or height. In other words the condylar heights, of which the anatomist is usually thinking (when comparing for example ape and man), may be very different while the natural lengths are nearly equal. The two heights are not really homologous quantities.

The borders of the patellar articular surfaces are so often damaged in the case of ancient bones that all measurements of both lengths and heights of condyles become doubtful. We have measured, however, σ_1, σ_2 and σ_1' where possible, in order to test statements as to differentiation between man and the apes made by various authorities.

(β_1) *External Condyle, Horizontal Band-Radius.*

(β_2) *Internal Condyle, Vertical Band-Radius.*

(I_β) *Band-Radial Index* = 100 Vertical Band-Radius/Horizontal Band-Radius.

These measurements suggested by Bumüller[1] are of very considerable interest, but difficult to make with any real degree of accuracy on many specimens. The *ligamentum laterale fibulare* passes from, roughly, the centre of the posterior portion of the lateral face of the external condyle, and the district of attachment of this ligament or cord, which plays a considerable part in maintaining the parallelism of the two portions of the lower member in man, is usually marked by a small smooth area behind or on the posterior face of the epicondyle (Diagram E, Plate III). The centre of this area can be marked and its distances from the infra-condylar plane (*Vertical Band-radius*) and from standard vertical plane (*Horizontal Band-radius*) measured in a considerable number of cases. In the living subject the former is usually larger than the latter, and the ligament is tightened by the femur being raised from the horizontal to the vertical position, as in passing from sitting to standing.

Bumüller[2] asserts that the vertical radius is always greater than the horizontal in man, while it is less for the apes. Of the generality of this principle there seems little doubt, but it is difficult to prove or disprove its universality. The reasons for this are as follows: (i) The fibular collateral ligament is attached to an *area*; this area is of a variety of shapes and cannot be said to have a true *centre*; the choice of "centre" is more or less arbitrary; (ii) in many femora the actual determination even of the area of attachment is very indefinite, in some impossible; and (iii) owing to the large number of bones with damaged articular margins the accurate measurement of the band-radii is often impossible. It is accordingly often impossible to assert that, in those cases in which the vertical is less than the horizontal band-radius, the difference is a reality and does not correspond to an error of measurement. Our measurements have been made with all the care possible and the impression formed in our minds is that the band-radial index is generally but not universally greater than 100 in man.

The Fundamental Triangle.

We now come to three points which require careful consideration for determination. The "vertical median plane of the head" is the plane through the axes of shaft and neck; it cuts the head in an arc, and the midpoint of this arc, usually just above the *fovea*, is the *centre of the head*, *C*. With the aid of the tape it is easy to mark *C* fairly accurately on the bone. It is also possible to mark the lowest point, *O*, of the median groove of the trochlea, *i.e.* when the bone is inverted the "summit of the pass" or highest point of the saddle between the condyles. Now place the bone horizontally with its anterior surface upwards on the universal clamp and adjust it till the median point of the top of the great trochanter, the centre of the head *C*, and the mid-trochlear point *O* are in one horizontal plane. Then project by aid of the contour tracer[3] onto this or a parallel horizontal plane that of the paper, *C* the centre of the head, *O* the mid-trochlear point, and the ends *BB'* of the minimum horizontal diameter of the neck; to obtain *BB'*, a portion

[1] Bibl. 81, pp. 81—82, 141. [2] Bibl. 81, pp. 82, 112, Tabelle II.

[3] The contour tracer we have used for projection possesses besides the tracing point a vertical knife edge which for present purposes gives a better result than the tracing point.

of both sides of the neck may be drawn in projection and the minimum diameter BB' then found. The line joining C to the middle point of BB' is the projection of the *axis of the neck.* Now project the transverse platymeric diameter (see (i) above, the position of *Pl. Dt.* should be pencil-marked on the bone at time of measurement) as EE' onto the paper, and join the middle point of EE' to the point O; this is the projection of the *axis of the shaft*[1], and we term the point where the projections of these axes meet the *coaxial point, D.* The triangle ODC is the *fundamental triangle* of the femur. The bone being still in the horizontal position, a vertical through the coaxial point D meets the posterior surface in the near neighbourhood of the inter-trochanteric ridge, close to, but usually somewhat below, the quadrate tubercle, and the anterior surface in the neighbourhood of the antero-intertrochanteric line or upper part of the spiral line, but as a rule external to it and below the tubercle of the femur. In the somewhat similar problem for the humerus this contour process of construction of the coaxial point has also been used. In our earlier work on the femur the points in which the line through the coaxial point perpendicular to the axes meets the posterior and anterior surfaces were marked by appreciation upon the bone, say at d_p and d_a; then the projections of Cd_p and Cd_a on the coaxial plane were measured and if nearly identical their mean taken as the *length of head and neck* or the capito-collar length. Similarly the mean of the projections of Od_p and Od_a was taken as the *length of shaft, OD*[2]. Lastly in both methods the distance OC from intercondylar point to centre of head, which may be termed the *capito-trochlear length,* was obtained. From OD, OC, CD the triangle OCD is determined, and thence the angle CDO between the axis of the shaft and the axis of the neck, the cervical angle. The sides and angles of the triangle CDO were measured by scale and protractor. Thus this process gives us:

(*t*) *Length of Neck and Head,* or the *Capito-collar*[3] *Length* (C.C.L., CD of Diagrams A and B, Plates I and II).

(*u*) *Length of Shaft, OD* of the triangle ODC (S.L., see Diagram A, Plate I).

(*v*) *Capito-trochlear Length,* the CO of Diagram A.

Angles of the Femur.

(*w*) *The Cervical* or better *Collar Angle* (α_{ns}, the angle ODC of Diagram A, Plate I).

[1] If a continuous thread be passed round the troclear notch and over the point where the spiral line meets the great trochanter it will from either posterior or anterior aspect be a fair approximation to the projection of the axis of the shaft. The "axis of the shaft" is of course a very vague term; if defined as the locus of centroids of cross-sections parallel to the standard horizontal plane, it by no means follows that it is a straight line or even a plane curve. See Bibl. 93, S. 293.

[2] This is the method followed by Warren (Bibl. 77, p. 137), but we were so dissatisfied with the results we reached that we re-measured the whole series by the process indicated above.

[3] We are fully aware of the ridicule which can be poured on the use of *collar* as an adjective,—chiefly by the ignorant, who do not know that such an adjective is already largely used in other fields and is justified by mediaeval *collare* and *collarius.* Cervical is not the proper adjective from *collum,* nor can we approve such Germanisms as "Collum-section" ("Collumquerschnitte") or "Collum Index." We do not say collum bone or cervical bone.

It must be observed that a considerable variety of methods has been adopted for determining both the capito-collar axis and the length of neck. Some authorities suppose the neck bounded by the antero-trochanteric line and bisect what they then term the base of the neck. This base as a rule is very ill-defined on the mesial side and the trochanteric line stands a good deal above the neck in the region of the summit of the trochanter major; thus bisection is not an easy task. The centre of this base is then joined either to the centre of the head or to the midpoint of the vertical diameter of the head. In the former case it does not follow that the line joining the centre of the cervical base to the centre of the head will pass through the centre of the vertical diameter of the head, nor in the latter case that the line joining the centre of base to the centre of vertical diameter will pass through the centre of the head. In fact we have the following points: (*a*) centre of base, (*b*) centre of minimum vertical diameter of neck, (*c*) centre of vertical diameter of head (which is approximately the centre of the articular hemispherical surface), and (*d*) the centre of the head. These four points by no means lie accurately on one straight line—the capito-collar axis. Compelled to select two of them[1] we have taken (*b*) and (*d*) as most capable of close determination. If the actual dimension of the neck be required we consider it as approximately equal to our capito-collar axis minus half the vertical diameter of the head.

Parsons, the most recent writer on the subject, says he first determines the axis of the neck, and he thus describes his process:

"In taking the axis of the neck, I have drawn a line from the middle of the base of the neck as seen from in front. The angle which this makes with the long axis of the middle of the shaft is the one I have taken (see fig. 1)[2]."

The description gives no explanation of how the base of the neck is bisected or indeed the base determined; nor are we told how to find the middle of the head; to judge by the diagram the middle of the head has not been found by bisecting the arc in the median plane of the head[3]. Again we are not told how "a line is drawn from

[1] Walmsley (Bibl. 112) adopts still another method of determining the axis of the neck; he defines it to be the line bisecting base line of head and "lying in the centre of the neck." He used a diopto-graph drawing. He defines the base line of the head as joining the margin of the articular cartilage at the highest point of the neck with the margin at the lowest point; this is clear, but it will not always be the same as the vertical diameter of the head. He defines the axis of the shaft as the line "extending through the centre of the bone" and which "if prolonged downwards would bisect the intercondylar line at the lower end of the femur." What are the centres of the bone and of the neck? If points, which points, and if lines why are they straight lines, and how are they to be drawn? What is the "intercondylar line" and how is it determined? We have no doubt that the author himself knows how he has determined the axis of neck and shaft, but he does not recognise how hard it is for the reader to discover what is meant by such terms as the "centre of the neck" and the "centre of the bone."

[2] Bibl. 111, p. 241.

[3] This view is confirmed by a phrase on p. 241 of Parson's paper: "A hole is drilled with a bradawl in the centre of the head of the femur—that is to say in the upper and front part of the fovea capitis." Our experience would show that the centre of the head is usually quite outside the fovea and this appears to be so in Parsons' fig. 1 (p. 240). Thus we are left in complete obscurity as to what point he really did select as centre of the head.

the middle of the head to the middle of the base of the neck." Is it done dioptographically or in imagination, or on the surface of the bone? In what plane does it lie, and if in no plane, is it a line at all? Further, what is "the long axis of the middle of the shaft"? In what plane is it to be drawn, and how does it meet the line which Parsons terms the long axis of the neck?

Again to get the "length of the neck" Parsons writes: "I measure it by resting a sliding scale along the front of the long axis of the neck, obtained as above. The head rests against the fixed bar of the scale, and the length is taken to the place where the long axis of the neck cuts the spiral line of the femur. Where this line is broad, the middle of it is taken[1]." This seems to suggest that Parsons has taken the "long axis of the neck" on the surface of the bone, otherwise it could hardly meet the spiral line. A little examination of the bone itself will show how different would have been the result had the operation been performed on the posterior face of the femur. Again unless he used specially designed calipers the length measured would be inclined to the axis of the neck and not a true measure of the "length of the neck" at all. Further it would not be the "length of the neck" in the sense used by the continental osteometricians, which is a measurement from the margin of the articular surface to the spiral line. What Parsons is seeking to measure is the length of neck + head, our capito-collar length. But under no circumstances is it comparable with our length, for Parsons' length does not extend to the coaxial point as will be seen at once from his figure 1 (p. 240); as he draws his diagram the vertical diameter of the head and his axis are not even approximately at right angles. His diagram seems to indicate that the vertical diameter of the head and the minimum vertical diameter of the neck are for that case nearly parallel, and a line from what appears to be the true centre of the head to the midpoint of the minimum diameter would have been approximately perpendicular to the vertical diameter, but it would have given a considerably greater cervical angle.

While admitting that all diagrams must be considered as merely "diagrammatic," we have had to see what Parsons may have done by aid of his diagram, because his descriptions appear to be most unclear. We do not in the least underestimate the difficulty of effectively determining either the axes of neck and shaft, the length of neck (+head), or the cervical angle, but, until a standardised process is adopted, it is essential to state exactly what has been done, or measurements will be compared, which are probably of totally different things. We believe that most of the values of the cervical angles found by different observers for different races may represent quite as much difference of procedure as difference of race.

Besides the cervical angle *ODC*, we have read off:

(ω_1) *The mid-trochlear angle*, or *DOC*.

(ω_2) *The angle at centre of head* or the *capital angle*, *OCD*.

Besides the capito-collar length, two further measurements were made on the neck:

[1] Bibl. 111, p. 241.

(n_h) *Collar Horizontal Diameter*, or the minimum horizontal diameter of the neck, taken wherever found.

(n_v) *Collar Vertical Diameter*, or the minimum vertical diameter of the neck, taken wherever found. The diameter is taken in the vertical plane through the axis of the neck, but like the vertical diameter of the head is not necessarily itself vertical.

It will thus be seen that n_h and n_v, although frequently in nearly the same plane, are not invariably so. Their ratio is the *Primary Index of the Neck*[1]: see ($\epsilon\epsilon$) below.

We considered at some length the possibility of determining a section of the neck in which both horizontal and vertical diameters might be measured, but came to no satisfactory result. τ_2 is the length from which the axis of the neck is found, but if we take τ_1 in the plane of τ_2 and perpendicular to it, it by no means follows that τ_1 is the minimum horizontal diameter, which alone is satisfactory as a means of measuring the slenderness of the neck.

Two further angles associated with the neck have been considered by Lehmann-Nitsche. First the angle between the vertical diameter of the base of the head and the axis of the neck. This is not absolutely a right angle and measures the set of the head on the neck[2]. Secondly the angle between the major axis of what Lehmann-Nitsche considers the "elliptic" cross-section of the neck, and the plane determined by the vertical diameter of the head and the axis of the shaft[3]. These angles—"set of head on neck" and "rotation angle of neck" we have not found it feasible to determine satisfactorily. Lehmann-Nitsche himself recognises the difficulty of determining the first in most adult bones. We do not consider that the cross-section of the neck is sufficiently accurately an ellipse, or that the particular cross-section in question can be closely enough ascertained to render the "rotation angle of the neck" a measurement capable of any real value.

(x_1) *Torsional Angle.* This is defined for the purposes of the present paper as the angle between the plane of the fundamental triangle and the standard vertical plane. We define the standard vertical plane of the femur to be the plane tangential to the posterior surfaces of the condyles and the inter-trochanteric ridge[4]; it is the *horizontal* plane of the osteometer when the bone rests in the standard position upon it, anterior face uppermost. The fixed vertical plane of the osteometer then touches the inferior faces of the condyles, and this fixed vertical plane is then the infra-condylar or standard horizontal plane of the femur. To allow for extreme cases of negative torsion it may be needful to place two blocks of the

[1] Our Primary Index of the Neck (Collar Index) differs essentially from Lehmann-Nitsche's "Index des Collumquerschnitte" = 100 minimum diameter of neck/maximum diameter of neck (Bibl. 69, S. 284—5). We failed to determine the particular cross-section of the neck of which the major and minor "elliptic axes" were to be determined.

[2] Bibl. 69, S. 287.

[3] Bibl. 69, S. 288.

[4] The point of contact is usually in or near the quadrate tubercle.

same height one under the posterior faces of the condyles and the other under the great trochanter, thus the neck and head can fall below the standard vertical plane (see Plates IV and V).

Any bone is said to be in its normal position when its standard vertical plane coincides with the horizontal board of the osteometer, and its standard horizontal plane with the fixed vertical board, *i.e.* when the bone is in the position for finding the oblique length. For the natural position of these standard planes we require to make the base-board of the osteometer vertical and the fixed board horizontal.

We next assume that the axis of the shaft is nearly parallel to the standard vertical plane. This, as in all attempts at accurate definition by points, lines and planes in osteometry, is only a very rough approximation to the truth. As a rule the axis of the shaft is neither a straight line, nor parallel to the standard vertical plane[1]. Thus it comes about that (i) our definition of the angle of torsion cannot be accurate, and (ii) we do not really use it. What we do measure is the angle between the standard vertical plane and the projection on the standard horizontal plane of a line treated as the capito-collar axis.

The process actually adopted to find the torsion was as follows: two boards at right angles were taken; the upper plane of one, horizontal, passed through the centre of the object glass of a camera, and the second, vertical, was parallel to the focal plane of the camera. The focussing screen of the camera was replaced by a sheet of ground glass and the image of the upper edge of the horizontal board provided a horizontal line which was drawn in on the ground glass. The femur was now placed in the standard position (see above) on the horizontal board, the infra-condylar plane coinciding with the vertical board, and the image of neck and head focussed on the ground glass, a strong electric light being cast on the head. The operator now drew with a pencil the anterior and posterior boundaries of the image of the neck on the ground glass and marked also on the glass the centre of the head from the marked point on the bone. The sheet of ground glass was now taken out of the camera, and the minimum horizontal diameter of the neck drawn and bisected, the line joining this bisection to the image of the centre of the head was taken as the projection of the capito-collar axis and the angle between this line and the horizontal base line measured with a protractor. This angle was taken as the angle of torsion. The drawing of the neck and the centre of the head was removed by a moist sponge, the ground glass replaced in the camera and the process repeated on another femur. Clearly our torsion is the angle between the fundamental vertical plane and a line taken to be the projection on the fundamental horizontal plane of the capito-collar axis. In order to follow

[1] It would undoubtedly be convenient to define an arbitrary line as the theoretical axis of the shaft. As inferior point it would be easy to take the mid-trochlear point *O*. The superior point *S* is more difficult of determination. It might possibly be taken on the line joining the centre of the head to the top of the great trochanter and at such a position that the plane through this axis perpendicular to the standard vertical plane bisected the transverse platymeric diameter. Only ample experience with the contour tracer could determine whether the point *S* thus determined divides the line from tip of great trochanter to centre of head in any constant ratio.

out accurately our first definition, we should require to determine far more definitely than has been done at present the axis of the shaft. And even then there would be no certainty that such an axis, as far as it represents any physical axis of the shaft, really lies in the same plane as the capito-collar axis. Nevertheless torsion is such a definite physical character of the femur that some attempt must be made to measure it: see Plates IV and V. Actually we believe that most anatomists appreciate the torsion by resting the bone in the standard position and then judging the torsion by the inclination of a supposed axis of head and neck to the horizontal. It will be seen that this inclination is precisely what we have endeavoured to measure by the above camera process.

How far does this differ from earlier methods of determining torsion? Broca in 1872 invented his "tropometer," although his description of it was not published until nine years later[1]. The instrument itself involves setting two pointers to the "axis of the condyles." Broca measured the torsion of over 600 humeri and 150 femora with his apparatus, but we do not know how he determined the axis of his condyles. Job in 1891[2] invented a "trepsimeter" which in some respects is an improvement on the tropometer. This also involves setting pointers to the terminals of the "axis of the condyles." Before we consider Job's determination of this axis, let us consider what the most recent writer has to say on the subject. Parsons tells us that a hole "is drilled in the internal condyle of the femur, starting on its inner side in front of the summit of the inner tuberosity, and running parallel to the surface of a table on which the femur is lying so that the back of each condyle is touching the table (see fig. 3, line *CD*). Into this another knitting needle is placed[3]."

Now here is the same vagueness that we have had frequently to complain of in Parsons' descriptions of what he has done! According to his description the above knitting needle might be *in any direction whatever* parallel to the standard vertical plane. If he really means that it may be, then why not use the standard vertical plane straight off without the trouble and danger of drilling a hole? If he means it to be parallel to the trace of the standard vertical plane on the infra-condylar plane, then that line is given to him by the osteometer at once and all his work to determine "the axis of the condyles" was not only unnecessary but a fruitful source of error. Without an adjustable drilling machine even those of us who have had workshop experience would find it impossible with a simple bradawl to drill a hole truly *horizontal*; most men would make an error of at least one or two

[1] Bibl. 26, p. 385 *et seq.* Broca was led to the subject by the discussion which followed the memoirs of Martin and of Meyer (Bibl. 4 and 7).

[2] Bibl. 53.

[3] Bibl. 111, pp. 241—2. We should like to enter a strong protest here against the growing custom of piercing holes in valuable and often unique craniometric and osteometric material. It not only risks the breakage of the specimen but it is apt to ruin the possibility of enquiry of other kinds at a later date. For example, Parsons has probably destroyed in his material any possibility of a later investigator dealing with the band-radii of the internal lateral ligament.

degrees and the untrained mechanic considerably more. Anyhow such a drilling was wholly unnecessary. The origin of the process in Parsons' mind, we think, must be sought in the fact that Broca used pointers to indicate the "axis of the condyles," but the reason for Broca's doing this was that in his opinion the "axis of the condyles is *not parallel* to the standard vertical plane. Parsons simply ignores all the discussion which has taken place on this very point, and his paper might well have been written in 1857, the date of Charles Martin's pioneer work. Job, who dealt very fully with this point in 1891[1], writes as follows: "Les insertions des ligaments latéraux de l'articulation indiquent évidemment les extrémités de l'axe autour duquel tourne la surface articulaire des condyles." But these insertions are *areas* and not "points anatomiques précieux pour indiquer les extrémités de l'axe transversal de cette épiphyse." Areas will not determine a true line, and this point is we think really recognised by Job for he notes that the insertions are irregular, "formées de dépressions et de saillies inconstantes, variables avec les os et seront difficilement appréciables sur les os jeunes." We may add that femora of a distant epoch and particularly disinterred material will frequently be badly damaged over these insertion areas.

Job himself apparently gives up these "points anatomiques précieux" and remarks: "la face externe des condyles est limitée en arrière par un bord assez exactement circonférential, dont le centre cherché avec le compas, se trouve justement au niveau des insertions ligamenteuses[2]." Our author considers that by aid of the compass we can thus obtain two mathematical (not anatomical) points and so determine a true line, and that this line is free from pathological modifications of the surfaces and individual variations of ossification. Now our comment here must be considerable. In the first place the edges of the condyles which are to determine these circles are in the majority of cases damaged. In the next place if they are not damaged, it is well to note that they do not form a sharp curve of any kind, not even a plane curve; it is proposed therefore to find the "centre" of a curve not lying in one plane by taking equal distances from its contour to a most irregular surface passing through that contour but nowhere on its level. Without insisting on the *mathematical impossibility* of solving this problem, we may state that in our opinion it admits of no practically valuable solution[3]. Practically only a small part of the condylar contour has even the same radius of curvature. We are quite unable to agree with Krause's drawings of the condylar contour which gives an arc of about 90° with an average radius of 19 mm. Even in Bertaux's reconstructions[4] from Krause's figures it will be found that the arcs are not circles of the radii marked on them. The fact is there is no such thing as an "axis of the condyles," and to try and find it is to follow a will o' the

[1] Bibl. 53, p. 27.

[2] *Loc. cit.*, p. 27.

[3] The inequality of the vertical and horizontal band-radii is evidence that no such "centre" exists.

[4] Bibl. 52, pp. 129—130. Bertaux's own diagrammatic sketches of internal and external condyles (pp. 132—3) give far greater inequality between the two condyles than seems to us on the average to exist.

wisp. The articular surfaces of the condyles act partly as roulettes and partly as glissettes and the axis of rotation changes continuously during the motion of the femur round the knee joint. The best expression of the curves involved would be by a median rather than by an edge section of the condylar articular surfaces, for this would be free of the extreme variations of the edge section. To a *very rough* approximation such sections are equal and circular on the posterior and inferior surfaces of the condyles, but to the extent to which they are such the condyles would be turning about an axis parallel to the standard vertical plane, and therefore this axis is determinable by simply placing the bone in the standard position on the osteometer. This is the only "axis of the condyles" we have felt able to admit. Our torsion is clearly the torsion out of the standard vertical plane, and this appears to have been the character considered by Martin and Hamy. Its validity has been denied by Lehmann-Nitsche and others who apparently take the most projecting points of the condyles, *i.e.* those that would be touched by the calipers in measuring the bicondylar width, but no proof has been given that such points correspond to any true axis of rotation; they are frequently defective in actual material (we were only able to take the bicondylar width in about 68 per cent. of our material) and further the friable condition of many bones would prevent the grip of the needles of Broca's or Job's instruments (much more the use of a bradawl!) at such points we are wholly in agreement with the view of Hultkrantz approved by Klaatsch: "Es ist nur in den späteren Phasen der Beugung, dass die Bewegungsachse annäherend fest liegt; dann ist sie aber auch der die hinteren Abschnitte der Kondylen tangierenden Ebene parallel und bildet denselben Winkel mit der Collumebene wie diese[1]."

We now come to the important point of marking the axis of the neck from the superior view, and we have here simply repeated our method of joining the centre of the head to the midpoint of the minimum diameter of the neck. This minimum diameter of the neck is now the minimum *horizontal* diameter of the neck as seen in projection on the standard horizontal (infra-condylar) plane. Our method is wholly different from that of Parsons. He says[2]:

> A hole is drilled with a bradawl in the centre of the head of the femur—that is to say in the upper and front part of the fovea capitis. The direction of the hole does not follow the long axis of the neck as seen from above, but is drilled in such a way that it would come out of the shaft just below the great trochanter, midway between its anterior and posterior margins (see fig. 3, line *AB*). This, I think, is important, as it is the torsion of the shaft which we wish to obtain. A long steel knitting needle is placed in this hole.

We are quite unable to follow Parsons' reasoning. He wishes to measure "the torsion of the shaft" and he fixes one point on the shaft although rather vaguely[3], but the second point is not on the shaft but in the fovea of the head,

[1] Bibl. 87, p. 614 *et seq.*

[2] Bibl. 111, p. 241.

[3] As before we can only say that even with workshop experience we do not believe that without a special adjustable drill it would be possible to make the bradawl come out where Parsons anticipates it would!

a very variable region and capable of being moved into all sorts of positions by change of direction of neck, set of head on neck, etc., etc. Hence whatever Parsons is measuring, he is not measuring an angle free of the neck to the slightest extent and we consider that he would have done more wisely to follow the usual rule of taking the axis of the neck. Had he wished to exclude the neck he should have taken for his second point on the shaft a point on the mesial face about the level of the trochanter minor, and about midway between this trochanter and the boundary (?spiral line) between mesial and anterior faces. There would be something to be said for such a measure of torsion, although in our opinion it could only supplement not replace the older method. We find no argument in favour of the innovation introduced by Parsons. It has only rendered his torsional values incomparable with those of other observers[1].

But there is a still more serious source of error in Parsons' measurements. He has got his two needles in position; how does he determine the angle between them? This of course ought to be done by an optical arrangement throwing the images of the needles on a plane nearly if not exactly perpendicular to the axis of the shaft. Parsons says, "formerly I threw the shadows of the two rods on a screen by a lamp placed in a line with them, then pencilled the shadows and measured the angle between them[2]." Clearly all will depend on the orientation of the screen relative to the bone; in the next place, "a lamp placed in a line with them" would refer to a source of light placed anywhere on the hyperboloid of one sheet generated by a line through the axes of the two needles, and the angle will therefore depend on the position of the lamp as well as of the screen. This appears to have been discovered by Parsons, for in his final method he seeks a special generator of this hyperboloid. Of course it should be the generator of the hyperboloid parallel to the axis of the shaft and perpendicular to the screen. Parsons takes it to be the generator joining the point where one needle comes out of the head and the other out of the internal condyle[3]. This generator, so far from being parallel to the axis of the shaft, makes a greater and greater angle with it, the greater the torsion of the bone. This will be at once apparent if the reader will examine a femur from the mesial aspect. We hold therefore that it is impossible to compare his and our results for torsion, just as it is impossible to compare his and our results for the cervical angle.

The lesson of course is twofold: (i) the need that exists for standardisation of the femoral measurements, and (ii) that standardisation should be based upon

[1] If the reader will examine Parsons' diagram, fig. 3, *loc. cit.*, p. 242, he will see that his construction gives in that case an angle of torsion of 16°, while the more usual procedure would only give one slightly less than 10°!

[2] *Loc. cit.*, p. 242.

[3] "The points at which the two needles come out of the femur are then got into line with the eye and the angle between the two rods measured with a transparent celluloid protractor with the bone resting on a flat surface about the level of the eye," *loc. cit.* p. 242. How was the protractor held, perpendicular to the shaft to the generator or in a vertical plane?

combined anatomical and geometrical knowledge. We are quite aware of the difficulties which surround the measurement of femoral torsion, but we think our determination gives approximately the same angle as French and German scientists would have provided. The "axis of the condyles," as far as it has any meaning, is parallel to the trace of the infra-condylar plane on the standard vertical plane. This trace is of course not perpendicular to the "axis of the shaft," neither is the capito-collar axis. The chief question is: What plane we shall project them on to in order to obtain the angle of torsion? The answer should be on a plane perpendicular to the "axis of the shaft." But this axis has not yet been rigidly defined; in our view it may have no physical existence as a *straight* line, and if it were defined *theoretically* as a line from the intercondylar point to a determinable point on the superior surface of the neck (or the meet of the platymeric transverse and antero-posterior diameters) a new instrument would have to be devised to determine the torsion, because although the tropometer would give a plane perpendicular to this axis it would not without considerable modification give also the "axis of the condyles" as above defined. To escape these difficulties we have for the present investigation projected our "axis of the condyles" and our capito-collar axis on the infra-condylar plane, a plane which owing to the obliquity is not accurately perpendicular to the axis of the shaft. But if t be the true angle of torsion, τ the angle found by our process, and ω the true obliquity of the shaft, it is easy to see that

$$\sin \tfrac{1}{2}t = \sin \tfrac{1}{2}\tau / \cos \omega.$$

Now the misfortune is that the obliquity of the shaft (o.s.) as measured by Broca's osteometer is not the true obliquity ω, but the angle between the perpendicular to the infra-condylar plane and the projection of the shaft on the standard vertical plane, and it is clear that the axis of the shaft slopes to the standard vertical plane, as it does to the standard horizontal plane. If we could once agree as to what should be considered the "axis of the shaft" a correction could be made for the difference of ω and o.s.; or it would be quite feasible to design a good instrument for setting the axis of the shaft into a definite position relative to the standard planes. It must be noted, however, that as $\frac{1}{2}t$ and $\frac{1}{2}\tau$ are small the difference of ω and o.s. only introduces terms of the second order into the above formula, and thus very approximately we can take

$$t = \tau\{1 + \cdot 00015\,(\text{o.s.})^2\},$$

where o.s. is the obliquity in degrees as measured in Broca's manner. Since o.s. is roughly about 10°, we must add about $\frac{1}{70}$ to the value of τ to find the true torsion. For example the mean male right femur in our data gives

$$\tau = 14^\circ\cdot 24, \qquad \text{o.s.} = 9^\circ\cdot 39,$$

which gives $t = 14^\circ\cdot 43$, agreeing to the decimal places recorded with the value determined by the fuller formula. Thus our method of estimating the torsion is not likely to produce an error in the mean values of more than $0^\circ\cdot 2$, and correction can be made if desired by the above formulae for the obliquity.

(x_2) *Torsion of Shaft.* It seemed to us that, the torsion of the neck and head being generally negative or a retorsion, it was very desirable to determine even if only in some approximate method the proportion of the torsion due to the shaft and to the neck and head. In order to achieve this we need to select a diameter of the shaft in the infra-trochanteric region. Such a definite diameter is very difficult to fix upon. It must be free of any relation to the head and neck, and must not be influenced by the small or large trochanter. After much consideration we could not find anything as good as the terminals of the platymeric antero-posterior diameter. These are marked points on the bone, and their neighbourhood provides two almost parallel and relatively flat surfaces upon which it is easy to clamp the torsiometer. Plate XXI exhibits from two aspects the instrument devised by one of us. It can be attached to the antero-posterior platymeric diameter by screws terminating in small planes or sharp points, the latter being generally more convenient; the line joining the centre of the protractor to the zero of the protractor-scale is then parallel to the antero-posterior diameter. The instrument is then turned round this diameter until the plumb-line just hangs freely, *i.e.* the protractor is in a vertical plane. The reading then gives the angle between the perpendicular to the standard vertical plane and the platymeric diameter, that is the angle between the standard vertical plane itself and the plane through the axis of the shaft perpendicular to the antero-posterior diameter. In practically every case the torsion thus measured was *greater* than the total torsion discussed under (x_1). In other words the main factor in torsion is that of the shaft, the torsion due to neck and head is a retorsion, or turning back on this primary torsion. This point has not we believe been hitherto quantitatively determined and adequately dealt with. The present torsiometer allows the retorsion to be easily found, and the two contributory factors to be considered independently.

(y) *Obliquity of the Shaft.* This is the angle between the perpendicular to the standard horizontal plane and the projection of the axis of the shaft on the standard vertical plane (o.s., see Diagram A, Plate I). It is read by the goniometer attached to the Broca osteometer[1]. The obliquity is often spoken of as the angle between the axis of the shaft and the standard horizontal plane. This is of course not true as the shaft axis is not parallel to the standard vertical plane, but the long arm of the Broca instrument is or should be so[2]. There is some judgment required

[1] That instrument is not very well designed; it is not possible to elevate and depress the goniometer; the result is that it is too high above slender bones producing the danger of parallax, while some massive femora will not go beneath it and have to be specially treated. Further the rod should be so adjusted that the reading is taken at an edge, not by its axis. The actual angle to be read is covered by the rod itself. Thus unless one removes the long arm of the rod before reading, which may easily upset the adjustment, one has to read the angles on either side of the rod and take their mean.

[2] Parsons' description is again so vague that we cannot say what he has measured. He writes (*loc. cit.*, p. 242): "*The obliquity of the shaft.* I measure with a goniometer having a long pointer, which can be placed in front of the long axis of the femur, the two condyles of which are resting on a flat surface. The angle recorded is that between the obliquity of the shaft and the vertical." How the obliquity of the shaft can be the angle between the obliquity of the shaft and another line we fail to

in placing the long arm of the Broca instrument appreciably parallel to the projection of the axis of the shaft, as it involves contemporaneous shifting of the bone and rotating of the arm. Our endeavour was to bisect the anterior surface of bone by the long arm at the sections where the transverse platymeric and popliteal diameters were taken. The danger of the present instrument arises from parallax. A wedge slipped under the great trochanter till the proximal end approaches the arm of the goniometer as well as the distal might improve matters, it would bring the shaft more nearly parallel to the base-board of the osteometer. But not only does this cause the condyles to rotate on both planes of the osteometer, but it renders the bone still more difficult to shift about. There should be a vertical and horizontal transverse motion of the goniometer possible to save readjustment of the bone. We have simply placed the bone on the osteometer and measured the obliquity in Broca's manner.

(*z*) *The pseudo-obliquity.* The angle α used by Dr Warren[1] must not be confused with our obliquity of the shaft angle. Dr Warren's angle α is obtained from $\cos^{-1}\frac{\text{vertical projection of oblique length}}{\text{maximum length}}$. The maximum length is only approximately in the same plane as the vertical projection of the oblique length, and the maximum length is not parallel to the axis of the shaft. We have not calculated the angle α, but its values for the mean bones as compared with the means of the obliquity of shaft are as follows:

English	Male		Female	
	Right	Left	Right	Left
α for mean femur	5°·97	5°·73	7°·70	7°·02
Mean obliquity of shaft ...	8°·69	11°·59	9°·39	11°·77
Mean α for Naqada	5°·79	—	7°·22	—

These results seem to indicate that the angle α is not a true measure of the obliquity of the shaft. The maximum sexual difference in the obliquity is 0°·7 in the right femur, and it is not possible to say that there is for English data a *conspicuous* sexual difference in the obliquity. But there is a very marked excess of female over male in the angle α. This excess appears to indicate, not as has been supposed greater obliquity in the female but possibly, for corresponding oblique lengths, a shorter length of capito-collar axis in the female.

grasp. Further, is the "vertical" the actual vertical or the vertical of the femur, and if so how is it determined? The two condyles can rest in a multiplicity of positions against a multiplicity of flat surfaces!

[1] Bibl. 77, pp. 136, 153—4.

Forming the index $I = \frac{100 \text{ capito-collar length}}{\text{oblique length}}$, we have

	Male		Female	
	Right	Left	Right	Left
English	17·33	17·36	16·82	16·74
Naqada	15·96	—	15·51	—

which shows that relative to the oblique length the female femur has a shorter head and neck. But it is not easy to see how a difference of 0·5 in this index would account for $1\frac{1}{2}$ to 2 degrees difference in the angle α. For were the capito-collar axis horizontal, which it is far from being, this could only correspond to an angular difference of about 0°·3. It will be noticed later that there is some, but not a very great sexual difference in the angle of neck and shaft. It appears therefore probable that it is some small differences in the shape of head or internal condyle, which largely modifies the position of the maximum length in male and female femora. If we take the index $= \frac{100 \text{ oblique length}}{\text{maximum length}}$, we have

Male		Female	
Right	Left	Right	Left
99·32	99·39	99·23	99·27

and it is on these very small differences in the indices that the large differences in α probably depend. An error of one millimetre in the estimation of the maximum length can change an index from 99·46 to 92·24, which corresponds to more than 1° of angle in Dr Warren's α. Thus even if the means of the indices or angles be significant, it is hardly possible to be sure of α for a single case to 1°, and this is of the order of the sexual difference involved. We are not, indeed, able to determine a small angle accurately from a cosine not accurately known to four significant figures.

This digression has been needful to explain why Dr Warren's measurement of the obliquity has not been recorded in the present paper. Its applicability seems to depend on the parallelism of maximum length and axis of shaft; this is not usually true, and even if it were true, a very small error in the determination of either oblique or maximum length would involve an error in Dr Warren's angle of the order of the sexual difference. It seemed best to measure the obliquity by Broca's instrument although that is by no means a markedly exact process. It does not in English material indicate any sexual difference in the obliquity, and the

sexual difference in the ratio of oblique to maximum length is produced rather by sexual differences in the shapes of the condyle and head than by sexual differences in obliquity[1].

The true nature of the difference between a and the true obliquity is indicated on Diagram A, Plate I. Here on the left of the figure we have drawn parallels to the axis of the shaft and the maximum length, and then rotated the maximum length round to obtain the angle a. It will be seen to be 2° to 3° smaller than the true obliquity, a result confirmed by a comparison of mean values.

Bowing. We now come to an important matter, namely the "bowing" of the shaft. Some measure of bowing is necessary, if we accept the view that the curvature of the Spy femur[2] is a racial feature, or if we need to determine the influence of bowing on pilastric development[3]. The question of measuring bowing was we believe first raised by Kuhff[4] in his paper of 1875. He simply takes it as the height of the highest point of the anterior surface above the standard vertical plane. He was followed in this by Bertaux[5]. This measure is obviously very fallacious. A robust bone with massive great trochanter and condyles, but with practically level anterior surface of diaphysis, would still have great bowing. Evangeli-Tramond, without giving reason for the choice, takes as his curvature measurement the distance from the "point culminant de la courbure de la ligne âpre[6]" to the standard vertical plane, so that he might actually be measuring as one factor absence of pilaster! In 1907 Antony and Rivet[7] approached the matter from a more scientific standpoint. They measured the curvature of the anterior face of the diaphysis. They determined the length from epiphysis to epiphysis as chord and measured the subtense of the anterior arc with Verneau's cephalometer. From chord (c) and subtense (f) they found

$$R = (c^2 + 4f^2)/8f.$$

As criticism of this we note that the above expression is only true for a circular arc, and that owing to comparative flatness near the epiphyses the frontal contour may have two points of inflexion. On this account we cannot agree with them that it is without great importance what points are taken as superior and inferior limits of the arc.

Lehmann-Nitsche[8] measures as Kuhff, the bone being in the standard position on the osteometer, the height of the highest point of the anterior surface above the base-board and terms 100 times this height divided by the maximum trochanteric length the index of bowing. Although he uses this index he notes that it is

[1] Dr Warren's figures (*loc. cit.* p. 153, and Plate 22, Fig. (i)) suggest that the maximum length of the femur is the distance between the point of contact of the internal condyle with the fixed vertical plane of the osteometer and the point of contact of the head with the sliding vertical plane when the femur is in the oblique position on the osteometer. We do not think this is correct; the maximum length may be 1 to 2 mm. greater and this is more than sufficient to account for the sexual differences in a found in this way.

[2] Bibl. 43 *bis*, Plate XX.

[3] Bibl. 57, p. 130 *et seq.*, and Bibl. 81, p. 29.

[4] Bibl. 19, p. 437.

[5] Bibl. 52, p. 180.

[6] Bibl. 65, p. 28.

[7] Bibl. 97, p. 226.

[8] Bibl. 69, p. 286.

"ungenau, da nicht angegeben wird, wo der höchste Punkt der Diaphyse liegt." He considers that the most accurate method would be a projection drawing of the anterior curvature of the diaphysis "viewed from the side," but he makes no use of this suggestion, nor does he state how he would quantitatively determine the bowing[1].

Bumüller[2] takes as usual an individual line, but we cannot think that in this respect he has been very successful. He appears, if we follow him correctly, to have placed his bone with its lateral side on the base-board of the osteometer and its posterior face against a vertical side wall of the instrument. Bumüller says that the bone was so placed that "die vordere Kontur mit einer der auf der horizontalen Messplatte befindlichen Längslinien zusammenfiel." We cannot understand this as the "vordere Kontur" would surely be not only a *curve*, but a curve raised above the base-board, and it is difficult to see how it can be made identical with a straight line. Bumüller next brings a broad set-square perpendicular to the base-board into contact with the platymeric region of the anterior face, and measures the angle which this set-square makes with one of the longitudinal lines of the base-board. It is difficult to follow his description, but at best all he seems to be measuring is the angle which a tangent to the platymeric area roughly parallel to a plane touching the bone laterally and itself perpendicular to the standard sagittal plane, makes with the standard vertical plane. We do not think it possible to consider this angle as a reasonable measure of the bowing, and (presumably owing to the inflexion?) Bumüller himself says his method cannot be applied when the central portion of the diaphysis is markedly bowed.

Guldberg[3] in 1905 follows Lehmann-Nitsche's suggestion of a projection drawing of the contour of the anterior surface, presumably of the whole diaphysial length, and he measures the subtense. But he appears more interested in the drawing itself than in a quantitative measure of the curvature. He found in 2 out of 90 femora no bowing (zero subtense), and he terms such the *infantile type*, because he found in newborn infants that the anterior surface was almost straight. He does not state whether he considered the subtense in these cases in relation to the length of the diaphysis. The maximum subtense was found either in the middle or somewhat nearer the proximal end, rarely nearer the distal end. It will be clear from the above that from Lehmann-Nitsche onwards the futility of Kuhff's "height above the table" measure of the bowing has been very fully realised.

The most recent writer, Parsons, on the femur, gives a measure of the antero-posterior bowing of the shaft. If we follow the description of his measurement correctly, he determines the distance from the standard vertical plane of the point of the anterior diaphysial surface furthest removed from that plane, and divides it by the

[1] Lehmann-Nitsche wrote in 1895. Already in 1893 Manouvrier had described as quite "illusory" the method adopted by Kuhff and Bertaux for measuring the bowing, *i.e.* the use of the maximum distance of the anterior face from the standard vertical plane. Bibl. 37, p. 130.

[2] Bibl. 81, S. 140.

[3] Bibl. 93, S. 295 *et seq.*

oblique length to obtain his index of bowing[1]. We do not think this index measures what is needed. It is invalid on the same grounds as the Kuhff measurement,—a short bone with massive condyles and emphasised intertrochanteric ridge would have a high index of bowing, even if the anterior diaphysial surface were quite flat!

The ideal theoretical method would be as follows: Clamp the bone with the standard horizontal plane horizontal, and draw in the manner of Michel[2] or that used by us for popliteal, pilastric and platymeric sections, a series of cross-sections parallel to this plane. Determine the centroids of these cross-sections by the Amsler Integrator, and plot these centroids, *in projection* on a plane perpendicular to both horizontal and vertical standard planes[3]. Assuming the actual "axis of the bone" to be a curve in space, a point which this process could be used to settle, this projection of the line of centroids is the nearest approach we could probably make to the solution of the problem of bowing. The chord of this, from platymeric cross-section to popliteal cross-section and the corresponding subtense, could then be found, and 100 subtense/chord taken as the index of bowing. Of course the curvature could be found from a knowledge of subtense and chord, but we believe that an index, *i.e.* a measure, quite independent of linear dimensions of the bone is essential. We take the chord from platymeric to popliteal cross-section in order to get rid of the inflexional tendencies between these sections and the epiphysial borders.

It stands to reason, however, that any application of this ideal method would be impossible in the case of a long series of bones, one bone alone would take a couple of days' work. We have accordingly proceeded as follows: The bone was placed with the standard sagittal plane horizontal, and standard vertical plane vertical, *i.e.* with condyles and intertrochanteric ridge against a vertical plane, the direction of the shaft being nearly horizontal; a "knife edge" projector[4] was then carried along the anterior surface of bone from the extremity of the popliteal antero-posterior diameter to the extremity of the platymeric antero-posterior diameter, these two extremities having previously been slightly readjusted by aid of a scribawl, while the bone was rotated a little on the standard vertical plane, so that they were at the same height above the horizontal plane. Thus the projection of the frontal contour is drawn on the horizontal plane, *i.e.* the original position of the standard sagittal plane. The projections $D_{pil.}$, $D_{pop.}$ of the extremities of the platymeric and popliteal antero-posterior diameters are especially noted. The chord $D_{pil.}$, $D_{pop.}$ is ruled in on the drawing, and the parallel tangent to it obtained by aid of straight-edge and set-square in the usual manner. The point of contact of this tangent gives the

[1] Thus his values are not comparable with Lehmann-Nitsche's, who used the maximum trochanteric length for his denominator.

[2] Bibl. 92 *bis*, p. 110. A good many interesting points as to the double curvature of shaft might be cleared up by Michel's method. We are unable to follow his mechanical discussion and believe it to be fallacious. Clearly the stresses in the bone depend on the moment of inertia, not on the area of the cross-section, and the bending moment considerations want more ample analysis.

[3] It is convenient to term this antero-posterior plane the standard sagittal plane of the femur; the plane has direction but not position.

[4] *I.e.* a Klaatsch contour tracer with the scriber replaced by a vertical knife edge.

maximum subtense fairly accurately, but as the position of the point of contact is subject to some error of determination, if the bone be fairly flat, the ratio in which the subtense divides the chord is less capable of accurate determination.

The drawings show at once the inflexional tendency in both platymeric and popliteal regions; they show further that the maximum subtense is as a rule nearer to the proximal end of the bone. On both these counts it seems to us impossible to use Antony and Rivet's diaphysial chord and subtense, which they assume may be used to find a radius of curvature from a circle formula. If we still continue to speak of a diaphysial chord and subtense the reader must remember that these are peculiar to our method of determining bowing, and that the former is not the length of the diaphysis.

Accordingly we have the following additional characters:

(A_1) *Diaphysial Chord.*

(A_2) *Diaphysial Subtense.*

(A_3) *Diaphysial Chord Segment*, or the distance from foot of subtense to proximal end of diaphysial chord.

(B) *Primary Index of Bowing.* $I_B = 100$ diaphysial subtense/diaphysial chord.

(zz) *Secondary Index of Bowing.* This is $100A_3/A_1$ (see below under Indices). It measures skewness of bowing.

Various authorities have taken a variety of other measurements not included in the above list. Thus some investigators take the mid-girth or the "grosseur" of the French anthropologists. We have been unable to convince ourselves that a tape measurement in the pilastric region can, owing to the difficulty of fitting accurately the tape in the neighbourhood of the *linea aspera*, be of any real service[1]. Again the girth of the head seems to us to be as accurately determined from the vertical diameter, or from the mean of vertical and horizontal diameters, multiplied by π as from actual measurement. We have entirely discarded the upper breadth ("obere Breite" of the Germans) as capable of small accuracy in determination and very far from homogeneous anatomically. We have also not taken the angle between head and neck, agreeing with Klaatsch that it is too vague a quantity to be determined reasonably without much expenditure of time and a long series of conventional directions, which would probably fail to become standardised.

Indices of the Femur. We have calculated the following, besides the platymeric, pilastric, popliteal, bandradial, collar and bowing indices referred to already.

(aa) *The Bicondylar Width Index* ($I_{s/a}$). This is 100 × bicondylar width/maximum length. It might be termed for brevity the *Bicondylar Ratio.*

(bb) *The Popliteal Bicondylar Index* ($I_{o/s}$). This is 100 × popliteal width/maximum bicondylar width, and might be conveniently termed the *Doffit Index.* This index as far as we are aware was first introduced by Hepburn[2], and may be

[1] The reader who wishes to convince himself of the difficulties attached to a tape measurement of the pilastric region should, if no series of femora are at his service, study Dr Warren's drawings of the pilastric sector on Plate 23 (Bibl. 77), or indeed those of our p. 8.

[2] Bibl. 71, p. 135.

taken as a measure of the manner in which the popliteal area expands to the condylar breadth, *i.e.* whether continuously as usually in the modern femur or more or less abruptly as in the *Pithecanthropus* femur: see the diagram on our p. 10. Klaatsch[1] used a similar index four years later, but he takes the popliteal transverse at 2 cms., not 4 cms., above highest point of patellar articular surface in front of external condyle. Our Plate XXXII illustrates the point to be brought out; W. 85 has the normal popliteal surface, but in W. 121, W. 285 and W. 104 we have approach to the Trinil femur in the shaft not spreading out till we get much closer to the condyles. The popliteal bicondylar indices for these bones are:

W. 85 : $I_{o/s} = 56{\cdot}6$, W. 285 : $I_{o/s} = 39{\cdot}1$,
W. 121 : $I_{o/s} = 43{\cdot}6$, W. 104 : $I_{o/s} = 38{\cdot}7$.

The index has just possibly some sexual importance, the shaft in the popliteal region being larger relative to the bicondylar breadth in the female than in the male. See Diagrams A and C, Plates I and II.

(*cc*) *The Pyramidal Popliteal Index.* This index is taken to be 100 × popliteal width/popliteal length ($I_{o/n}$, see Diagram A). It is a measure of the pyramidal form of the popliteal surface, which, roughly speaking, is of "Eiffel Tower" shape. Although the determination of the apex is not very definite we think this index may have service for its racial value; it is not a sexual character.

(*dd*) *The Primary Capital Index.* This is 100 × maximum horizontal diameter of head/maximum vertical diameter ($I_{g/f}$). This index is a measure of the perfection of the hip-joint as a Hooke's joint, and is therefore of considerable interest. In modern European man, however, we do not find it more perfect than in primitive man (13 Cromagnon femora give 100·00 exactly!) or than in the lower races or the anthropoid apes. It may be termed the *Ellipticity of the Head.*

(*ee*) *The First Capito-collar Index.* This is 100 × vertical diameter of head to length of capito-collar axis ($I_{f/t}$). It is a measure of the relative slenderness of the capito-collar system.

(*ff*) *The Second Capito-collar Index.* This is 100 × ratio of lengths of capito-collar axis and of shaft ($I_{t/u}$).

In order to study the properties of the neck, its minimum vertical diameter (n_v) and its minimum horizontal diameter (n_h) were measured, that is to say its minimum diameter parallel to the standard vertical plane, and its minimum diameter perpendicular to the plane.

(*EE*) *Primary Index of the Neck.* This is 100 × minimum horizontal diameter of neck/minimum vertical diameter (I_{n_h/n_v}). It measures the *Ellipticity of the Neck.*

(*FF*) *Secondary Index of the Neck.* This is 100 × minimum horizontal diameter of the neck/minimum horizontal diameter of the head ($I_{n_h/g}$).

(*gg*) *The Third Capito-collar Index.* This is 100 × ratio of the capito-collar length to the bicondylar width ($I_{t/s}$). This index is of some interest owing to the near equality of the two lengths. We may term it the *Epiphysial Ratio.*

[1] Bibl. 87, p. 654.

(*hh*) *The First Transversal Ratio.* This is 100 × ratio of the pilastric transverse diameter to the platymeric transverse diameter ($I_{l/t}$). We term it the *Index of Gracility* (*upper*).

(*ii*) *The Second Transversal Ratio.* This is 100 × ratio of the pilastric transverse diameter to the popliteal transverse diameter ($I_{l/o}$). We term it the *Index of Gracility* (*lower*).

These two Transversal Ratios are measures of the deviation from the transverse uniformity of the shaft in the gorilla.

(*jj*) *The First Shaft Index.* This is 100 × ratio of the pilastric transverse diameter to the length of the shaft ($I_{l/u}$). It is a measure of the slenderness of the shaft from the anterior aspect. We term it the *Index of transverse slenderness.*

(*kk*) *The Second Shaft Index.* This is 100 × ratio of the pilastric antero-posterior diameter to the length of the shaft ($I_{k/u}$). It is a measure of the slenderness of the shaft from the lateral aspect. We term it the *Index of sagittal slenderness.*

(*ll*) *The Index of Popliteal Skewness.* This is 100 × ratio of the direct to the oblique antero-posterior diameter of the popliteal region ($I_{p/q}$).

The Chief Length Indices.

(*mm*) *The Direct-Oblique Length Index.* This is 100 × ratio of oblique to maximum length of femur ($I_{d/a}$).

(*nn*) *The Direct-Oblique Trochanteric Index.* This is 100 × ratio of trochanteric oblique to direct length ($I_{e/b}$).

(*oo*) *The Secondary Capital Index.* This is 100 × ratio of vertical diameter of head to maximum length ($I_{f/a}$).

(*pp*) *The Fourth Capito-collar Index.* This is 100 × ratio of capito-collar axis to maximum length ($I_{t/a}$). We term this the *Primary capito-collar longitudinal Index.*

(*qq*) *The Bicondylar Trochanteric Index.* This is 100 × ratio of bicondylar width to trochanteric length ($I_{s/b}$). Klaatsch[1] appears to prefer this to (*aa*); but we doubt if there is much stress to be laid on the difference.

(*rr*) *The Fifth Capito-collar Index.* This is 100 × capito-collar length/oblique length ($I_{t/d}$). Both (*pp*) and (*rr*) are needful for comparative purposes, as some authorities have used one and some the other. This is the *Secondary capito-collar longitudinal Index.*

(*ss*) *The Condylar Trochanteric Index.* This is 100 × ratio of external condylar length to trochanteric length ($I_{\sigma_1/b}$).

The above seem to comprise the most important and suggestive length indices of the femur. We have also determined:

(*tt*) *The Index of Robusticity of the Femur.* This is 100 × ratio of the sum of the pilastric diameters to the oblique length ($I_{(k+l)/d}$). Such an index has been much used by French writers, but they usually take the pilastric girth.

[1] Klaatsch defines his index as we have stated it, but appears to use the *inverse* ratio.

(*uu*) *The Index of Robusticity of the Head.* This is 100 × ratio of sum of diameters of head to the oblique length ($I_{(f+g)/d}$). A similar index is used by French writers using the girth of the head.

(*vv*) *The Condylar Index.* This is 100 × maximum external condylar length/bicondylar width ($I_{\sigma_1/s}$).

(*ww*) *The Third Capital Index.* This is 100 × vertical diameter of head/bicondylar width ($I_{f/s}$). It is like (*gg*) convenient as a measure of the relative development of proximal and distal epiphyses. This is the *Capito-bicondylar Index*[1].

(*xx*) *The Condylar Lengths Index.* This is 100 × the ratio of external condylar to internal condylar maximum length (I_{σ_1/σ_2}). It is held by Bumüller and Klaatsch to be a very distinctive differential criterion between the femora of modern man, primitive man and anthropoid apes.

(*yy*) *The Popliteal Shaft Index.* This is 100 × popliteal length/length of shaft ($I_{n/u}$).

(*zz*) *The Secondary Index of Bowing.* This index, already referred to p. 36, is 100 × distance from foot of diaphysial subtense to proximal end of diaphysial chord/diaphysial chord (I_{A_2/A_1}). This index is a rough measure of the skewness of the bowing.

Various additional indices have been used by other investigators. In several cases they are open to criticism. The above seem, however, to form a sufficiently comprehensive system for describing the main characteristics of the femur and for comparison with earlier determinations.

[1] The reader will probably have noted in the terminology for these indices how inconvenient it is that we have no single name for the combined neck and head of the femur, *i.e.* the portion of the femur separated off by the intertrochanteric ridge and the antero-intertrochanteric line. We suggest the name "bust." (*pp*) and (*rr*) might then be much more simply termed the primary and secondary bust ratios.

CHAPTER II

ON THE SEXING OF THE FEMUR

Perhaps the gravest difficulty associated with a study of the long bones is the difficulty of sexing them. One of the main objects of sexing—apart of course from the avoidance of the statistical difficulties arising from heterogeneity of material—lies in the desire to discover sexual differences in the skeletal frame. But if *a priori* we lay stress either in the long bones or in crania on any features as sexual criteria, we naturally find that they are sexually differentiated characters when we come after sexing to measurement. This evil is immensely emphasised when the anatomist has a personal preference for sexing by one or, perhaps, two special characters[1]. Thus one anatomist lays stress on the nasal bridge, another on an "infantile forehead," a third on the frontal sinuses, a fourth on the mastoids, a fifth on the "size of the neck" in sexing crania; the result of measurement in all such cases will be to emphasise the sexual differences due to these characters; and this not uncommonly confirms the individual in the choice of his peculiar characteristic. In order to avoid this very specious reasoning we need standard series of measurements on material wherein the sex is definitely known. Such series can be obtained only (i) by measurements on the living, (ii) by measurements in the post mortem or dissecting rooms, or (iii) by measurements on skeletal remains, where the sex is archaeologically determinable. A process less definite than these as applied to the long bones, but often of value, arises in the case where the whole skeleton has been found *in situ* and preserved apart. In this case a judgment of sex can be made from the cranium or pelvis which is distinctly more weighty than if the judgment as to the sex of an isolated long bone has to be made from that bone alone. In the case of the Naqada long bones not only were, as a rule, all the long bones of one skeleton known, but usually the pelvis and cranium were also present, and judgment as to sex was for Dr Warren a fairly easy matter[2]. In the case of our English femora from plague pits or clearance pits there was no chance of reconstructing the skeletons; each bone had to be judged by its own features, and the problem thus became much more difficult.

Of the three methods we have referred to above but little help can be obtained from the first; the presence of enveloping tissues renders any real appreciation of the usually fine sex-differences exceedingly improbable by direct measurement. A more

[1] In the "anatomical" sexing of the present series of bones the judgment has been made on as wide a series of characters as possible.

[2] Bibl. 77, p. 138.

hopeful line of attack might be developed by aid of stereoscopic radiography, and something would be worth while attempting in this direction. The second method of research was suggested in a circular issued in 1899 by the present writer in conjunction with Professor Bertram Windle to the chief English and foreign anatomists pressing for measurements on the long bones of corpses similar to those of Rollet in France. This appeal produced practically no results in England, but met with sympathetic attention from Professor Gustav Schwalbe[1]. Unfortunately, when nearly 200 corpses had been measured in Strassburg, a catastrophe has swept the material out of sight, and the chance of its ever being available for biometric treatment now appears small.

The third method seems to be capable of considerable expansion beyond what has at present been achieved. A request to Professor Flinders Petrie to bring home all long bone material the sex of which could be archaeologically determined from features of the grave or wrappings has led to the possession by the Biometric Laboratory of a considerable amount of sexed material. When the buildings of the new Laboratory are opened it is proposed to exhibit alongside each other collections of male and female long bones. The collections will not be large enough to reach by measurement sexual differentia, but it is hoped that the inspection of the series will be of considerable help in classifying bones of unknown sex. These collections were not available for the sexing of our present material, and we therefore had to fall back on other processes of estimation. We appealed in the first place to several anatomists, but their reply was discouraging when considered from the standpoint of how definite such sexing from the purely anatomical appreciation was likely to be. Some light is thrown on the whole subject by a paper of 1904[2] by Professor Thomas Dwight of the Harvard Medical School. Dwight sums up earlier literature on bone-sexing, and states the case before the publication of his paper as follows:

"The femur again is a bone that is to the expert of much value. A typical male and a typical female femur can hardly be mistaken; but practically there are a great many thigh bones, perhaps 75 per cent., on which an expert would be unwilling to give an opinion by methods hitherto in use. Without going as far as Professor Brinton[3], we may say that with our present methods, excepting the pelvis, and even this is not always conclusive, in the great majority of cases the expert must form his opinion of the sex of bones from their general appearance, and that comparatively rarely can he speak (still excluding the pelvis) with any great certainty[4]."

Dwight proposes to get over this difficulty for the long bones generally by paying attention to the relatively smaller size of the articular surfaces of the long bones in the female, and considers especially the heads of the humerus and the femur. He dealt with the problem by aid of the method classified as (ii) above, and measured 100 male and 100 female bodies, used for anatomy and surgery in the

[1] Since this paper went to press Gustav Schwalbe has passed away. Amid the clash of arms which has brought out the real small-mindedness of many acclaimed scientific authorities, we would wish to pay our poor tribute to a singularly suggestive, accurate and generous minded German scientist.

[2] Bibl. 90, pp. 19—34, 1904.

[3] Who declared that "Apart from the pelvis there is no guide to the sex among the bones."

[4] *Loc. cit.* p. 19.

Harvard Medical School. He took the measurements of the head of the femur *with the cartilage still fresh*, and the bodies were those of adult whites; he does not pay attention to right and left bones separately. He finds

Mean maximum diameter, head of femur ♂ ... 49·68 mm.
„ „ „ „ „ ♀ ... 43·84 „

This maximum diameter is taken wherever it is found without regard to position.

The difference in means is thus considerable, and marks a noteworthy sexual *mean* difference of 5·84 mm. The problem, of course, is the relation of this difference to the "overlap," *i.e.* considered in relation to the variability or standard-deviations of the male and female bones. Dwight considers the similar difference in the lengths of 200 femora, of which the data were provided by Hrdlicka. He gives

Average "length[1]," male ... 449·5 mm.
„ „ female ... 415·5 „

Here the difference is 34·0 mm., and Dwight appears to consider that this difference is less important than the difference in the diameter of the head because it is a less proportion of the mean quantity measured. Or, as he puts it, the female is 92·44 °/₀ of the male in the length of the femur, and only 88·24 °/₀ of the male in the case of the diameter of the head. Of course, such mean proportions are wholly idle for sexing unless in each case the differences be considered in relation to the variability of the characters under consideration. Dwight states definitely on p. 27:

"It is very evident that the difference between the bones of the arm and thigh in the matter of length are much less important sexually than those of the diameters of the heads."

As a matter of fact, it is questionable whether there is really much in the difference, and what there is could only be accurately determined by a consideration of the mean differences in relation to the variabilities. Such a crude process as that of comparing sexual "overlap[2]" to total range of both sexes gives:

	Length of Femur	Diameter of Head
$\frac{\text{Sexual Overlap}}{\text{Total Range, both sexes}}$ =	·41	·43

and shows that there is slightly more relative overlap in the case of the diameter of the head! Of course, this is a very crude test, but it is better than nothing at all, and it does not bear out Dwight's statement[3]. We shall show in Chapter IV that

[1] I presume this was the "oblique length." All Dwight says of the length is: "The length of the thigh bone was taken by the bicondylar method" (*loc. cit.* p. 27).

[2] We do not hold Dwight's attempt to remove extreme "overlappers" justifiable; the same process might be used equally legitimately (or illegitimately!) to remove extreme cases in the total range as well. Both processes are dangerous when the number measured is so few.

[3] "When the work was far advanced I regretted that I had contented myself with measuring only the heads instead of taking the length and perhaps the thickness of the bones. Although as a practical anatomist I know no one would think of determining the sex of either of these bones by its length, I felt that it would be difficult to answer anyone who might ask how I could be certain that there is a greater discrepancy between the articular heads of the bones than between the lengths" (*loc. cit.* p. 26). Dwight does not seem to have really got that answer from Hrdlicka's data.

there is a nearly equal sexual difference in several other characters of the bone, and that to give special weight to one or other individual character is likely to be misleading. Examining Dwight's diagram, given in a modified form on p. 45, we think we may say that a femur with diameter under 44·5 mm. may, *for this character in Dwight's material*, be recorded as ♀; that between 44·5 and 45·5 it may be recorded as ♀?; that over 49·5 it may be recorded as ♂; and that between 48·5 and 49·5 it should be recorded as ♂? Lastly, between 45·5 and 48·5 the only information from size of the head to be recorded should be sex doubtful—or with the symbol we have adopted elsewhere, ♁.

Similarly with regard to absolute oblique length in Hrdlicka's data, femora under 400 mm. may be recorded as ♀, between 400 and 410 as ♀?, over 470 as ♂, between 450 and 470 as ♂?, and finally between 410 and 450 as ♁ or of unknown sex. No stress whatever is to be laid on the actual values of the above numbers; we have no right to apply them directly to other or to dry material, because: (i) these measurements have been made on markedly heterogeneous populations—those of the dissecting-room material in Boston and New York—and (ii) there is the difficulty of making due allowance for cartilage[1].

Parsons, in his recent paper on "The Character of the English Thigh Bone[2]," appears to have disregarded these points. He compares his means for diameter of head with those of Dwight as follows:

Head of Femur.

	♂	♀
Parsons:	49·0	43·4
Dwight:	49·5	43·8

But unless there is no racial variation in the head we should not expect this correspondence, for:

(*a*) Parsons' and Dwight's material must be different in race and period;

(*b*) Parsons' bones were dry and Dwight's moist;

(*c*) Dwight himself tells us to deduct 2 to 3 mm. for cartilage from his measurements and not the 0·5 mm. difference found by Parsons.

As we have said, we do not know whether Dwight means 2 mm. to 3 mm. to stand for one or both thicknesses, but it seems to us that (i) Parsons ought to have inferred that his Rothwell population of the middle ages had a femur at least as differentiated from the modern American population as Maori from modern British; and that (ii) his dichotomies for sexing, which he confessedly based on Dwight, ought to have been reduced by anything from 2 to 4 mm. if he were going to apply measurement on moist bones with cartilage to dry bones without cartilage, even if of the same race. The large differences which such changes will make in his definite sexing are obvious, but we cannot believe that he has any right, even on the basis of

[1] Dwight says he went to great trouble in the matter, and thinks 2 mm. to 3 mm. should be allowed for cartilage in the head of the femur. We presume him to mean *altogether*, but he does not distinctly state whether it includes both ends of the diameter.

[2] Bibl. 111, p. 253 *et seq.*

Dwight's results, to adopt 45 mm. to 47 mm. as the range of primarily undetermined sex. On Dwight's own showing it should be something like 42 or 43 mm. to 44 or 45 mm. But if Parsons had adopted these values, he would have found very different sex groups, or he would have been obliged to say that his material and Dwight's were racially distinct—as, indeed, we think they certainly are. But in this case, what becomes of his application of Dwight's sexual tests to the Rothwell material[1]?

But even in Dwight's material, can any justification whatever be found for treating all bones over 47 mm. in head diameter as male? Of the 35 femora with diameters of 48 mm., 14 are ♀ and 21 ♂ according to Dwight, or 2 out of every 5! It is impossible, on any rational theory of sexing, to write against such bones anything but ♂—*i.e.* sex undetermined—for this character.

We have spent some time over this matter of the sexing by aid of the head of the femur because, although we do not believe in the rules provided by Dwight, still less in Parsons' application of them to his own material, nor in sexual difference being *much* more marked in the head of the femur than in several other characters, we still think that measurements made on the bones of the corpse would be of great service in deducing practically mechanical methods for sexing bones, when proper allowances are made (i) for moisture of bones and presence of cartilages, and (ii) for reduction of racial differences to a common norm.

Let us explain our ideas on the subject. The measurements made in the dissecting-room will hardly exceed 100 to 200 of each side and sex, if we confine ourselves to adults. The resulting frequency-distributions will therefore be irregular, and liable to tempt the uninitiated to assert that "outliers" of either sex may be neglected as "abnormal[2]." They must be graduated by smooth frequency curves, and here the normal curve will probably suffice to give the distribution sufficiently closely. From these curves we can deduce something like rules for sexing by the character under consideration. A dichotomy which gives, at that character value, only n°/₀ males, where n is a small number, may be taken to mark the bone for this character as ♀; one where only n°/₀ are females as ♂; dichotomies which give only n°/₀ to m°/₀ males, where m is a moderate number, and again only m°/₀ to n°/₀ females, may be used to form the classes ♀? and ♂? respectively; while between the dichotomies with m°/₀ males and m°/₀ females we frankly record the bone as of unknown sex (♂). We have now five classes, and these categories should be made

[1] There is another point arises here: Dwight takes *equal* numbers of both sexes, but our judgment would be much modified, if we had examined Dwight's graphs for very disproportionate numbers of the two sexes; the female adults would probably in any living population exceed males, but in any ossuarium will this be true? The female bones are slightly more slender and perhaps less likely to be preserved, while in more primitive society the grave of the male may be of a better protected character, or more significant and easy of discovery. The larger sex group will always show the more "stragglers" for small totals.

[2] "The amount of overlapping was wonderfully reduced by the elimination of a few stragglers," "the wide spread of overlapping is due to a few aberrant specimens." "What is most remarkable is that after this elimination of extreme formations the overlapping is limited to diameters of 45 and 46 mm."—all sentences due to Dwight and indicating an insufficient knowledge of the law of distribution of anthropometric variations in small samples.

DIAGRAM I. Dwight's Data, Measurements in Post Mortem Room. Maximum Diameter, Head of Femur. Sex known.

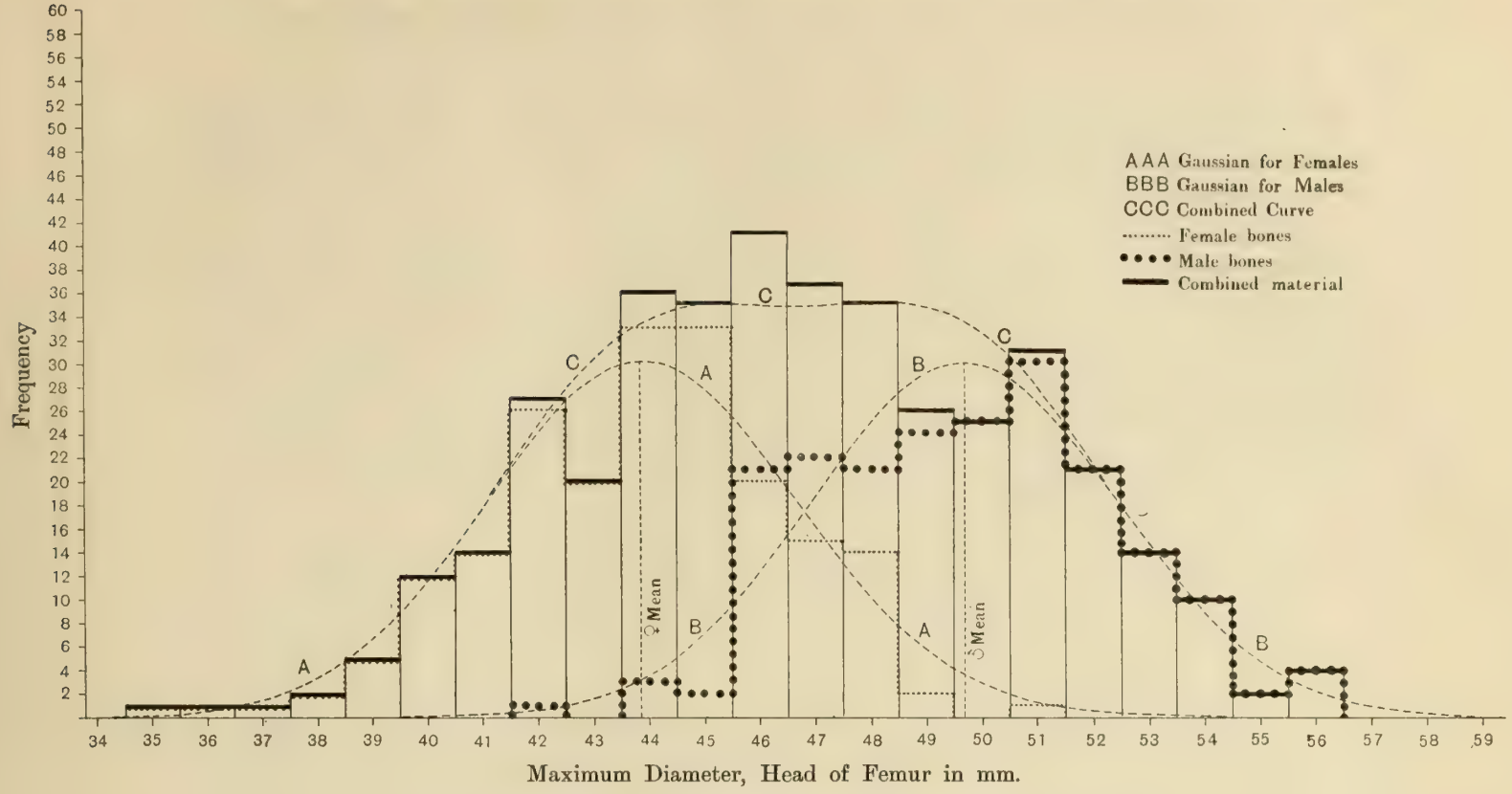
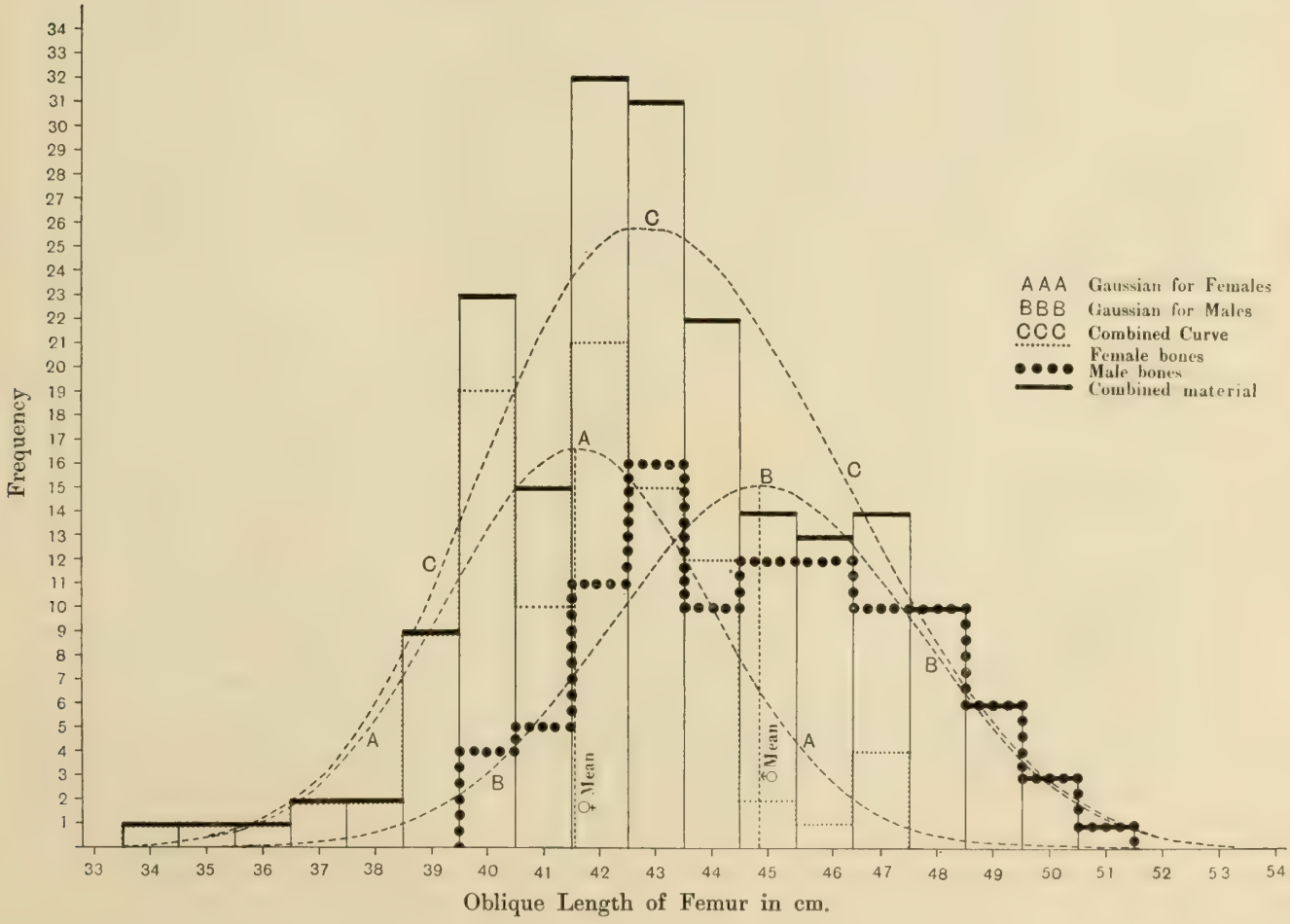


DIAGRAM II. Hrdlicka's Data. Oblique Length of Femur. Sex known.



for, say, 4 to 6 suitable characters. We thus obtain for each bone using six characters a series like: ♀, ♀?, ♀, ♂?, ♀?, ♂. The balance of such a classification will almost invariably determine the sex of the bone as definitely as we know the sex of a cranium. In our actual work on these lines we gave a mark +2 for ♀, +1 for ♀?, 0 for ♂, −2 for ♂, −1 for ♂? The above series indicates femaleness by 5. Bones with zero may be marked ♂, or, better, settled by general anatomical appreciation as ♂? or ♀? Into which classes we may also put bones of 0 to −2 and of 0 to +2 respectively. The accompanying Diagrams I and II represent Dwight's data for the head of the femur and the length of the femur reduced in this way, and show suitable dichotomies. The actual choice of n and m is not of such importance as might at first sight appear, if all characters are given approximately the same n and m.

The following values have been taken, based on the fitted frequency curves:

$$n = 8\,{}^{\circ}\!/_{\circ} \quad m = 25\,{}^{\circ}\!/_{\circ}.$$

Hence, for *fresh* bones, we have the sex-scales running thus in round numbers:

Femur	♀	♀?	♂	♂?	♂
Maximum Diameter of Head. mms.	< 43·5	43·5—45·5	45·5—48·5	48·5—50·5	> 50·5
Oblique Length. cms.	[> 37·5][1]	37·5—40·5	40·5—45·5	45·5—47·5	> 47·5

But these results clearly apply to moist bones with the cartilages attached, and to the somewhat heterogeneous white material of Boston and New York dissecting-rooms. How can we test whether it would be legitimate to apply them to our seventeenth century English material? We take, first, the head of the femur. We have measured vertical and horizontal diameters of both sides independently, ♂ and ♀. Dwight has not distinguished side and has measured the maximum diameter wherever found, ♂ and ♀. The results to be compared for the means—our sexing being independent of Dwight—may be tabled as follows:

Head of Femur in mm.

Dwight Maximum Diameter		London Seventeenth Century Femora				
		Side	Vertical Diameter		Horizontal Diameter	
♂	♀		♂	♀	♂	♀
—	—	R.	47·1	41·1	46·6	40·7
—	—	L.	46·8	40·8	46·4	40·5
49·7	43·8	R. + L.	47·0	41·0	46·5	40·6

[1] Even this is rather generous, but might be allowed in view of the abrupt cut-off of males at 39·5 cms., which, however, suggests some rejection of small male corpses.

As the vertical diameter is for both sexes greater than the horizontal diameter, we may compare this against Dwight's values. The excess of Dwight is nearly the same in the two cases, *i.e.* 2·75 mm. Assuming, therefore, that Dwight meant 2 to 3 mm. to stand for the whole effect of the cartilage, we can very reasonably consider that Dwight's numbers as given in the above table would apply to the sexing of our London material if, 3 mm. say, be subtracted from the limits of each category for moisture and cartilage[1].

We now turn to the oblique femur length as measured by Hrdlicka. The following table contains comparative results:

Length of Femur in cms.

Dwight-Hrdlicka			London Seventeenth Century Femur		
Side	♂	♀	Side	♂	♀
R.	44·95	41·55	R.	44·44	40·64
L.	—	—	L.	44·55	40·52

These results would seem to show either (i) that our material is significantly different from Hrdlicka's, or (ii) that he measured his without cartilage attached. Otherwise we think there should be at least a difference of 1·5 to 2·5 mm., while we only find 0·5 mm. for males and 1·0 mm. for females. Parsons gives for his ♂ R., 45·3; ♂ L., 45·6; and for his ♀ R., 41·5; ♀ L., 41·8; while Hepburn gives for 42 modern British (nearly all male, R. and L. together, and probably all Scottish), 45·9 cms. The difference between the London and modern Edinburgh data may well be due to racial differences, but if Hrdlicka's femora were measured moist and with tissues attached, the New York material is sensibly shorter than the London or Edinburgh[2]. There seems small chance of our being able to use the Dwight-Hrdlicka femora lengths for sexing purposes, and we are not acquainted with other dissecting-room measurements of equal or greater frequency which could be used to obtain the 4 to 6 characters requisite for efficient sexing by this method. Quite clearly archaeological sexing of the dry skeletons would be far more satisfactory than dissecting-room measurements (unless the bones are preserved) for the purpose we have in hand, but it may be long before fairly homogeneous material in large enough quantity is available.

[1] On the other hand, we do not see how it is possible to apply Dwight's results to Parsons' Rothwell data, unless we allow for a racial difference from the London bones, or suppose the selection from the Rothwell material has not been random. In either case Dwight's results cannot be directly used for sexing the Rothwell bones.

[2] It is, of course, possible (i) that Hrdlicka removed or allowed for the tissues, (ii) that the expression "length taken by the bicondylar method" used by Dwight does not refer to the oblique length.

The reader may ask, Is it not possible to obtain the two sex-frequency curves, as drawn in Diagrams I and II, from the material itself without appealing to material whose sex has been recorded archaeologically or is known at death?

The answer is in the affirmative, provided (i) we assume the male and female components to be both normal frequency curves, and (ii) there is adequate material to get a result fairly free from the very big errors of resolution which arise in the case of small samples.

The method is that of Pearson's first contribution to the mathematical theory of evolution[1], which deals with the resolution of compound material into its components. There is little doubt in our minds that such a resolution can be very effective, if we assume the Gaussian or normal form of frequency, and if we have a considerable population. The Gaussian curve applies with such close approximation to many craniometric frequencies, and to anthropometric measurements on the living, that we have considerable justification for applying it in the present case. The weak points are the usual inadequacy of material in osteological problems and the considerable labour of the process, the latter point being of far less importance than the former. Further, it is possible to reduce the labour by fitting a Gaussian to such portion of one or other tail of the heterogeneous distribution as we can safely assume to be uniform in sex[2]. The difficulty of this method is that if we obtain, say, the Gaussian G_f from the female tail and the Gaussian G_m from the male tail, it does not follow that $G_f + G_m$ will coincide even in number (area) with the total observed population, and this divergence may be very considerable, when we are fitting a Gaussian by aid of a tail which contains, perhaps, or indeed usually in osteological cases, only 50 to 100 individuals. It seems better, therefore, to proceed as follows: Cut off a portion F of one tail of the combined frequency curve, and fit a Gaussian G_f to this portion F assumed to be wholly female. Then subtract from the total frequency *on the male* side of the dichotomic line the part of G_f also on the male side, and fit a Gaussian G_m' to the remainder. We thus reach, in number and mean, only the required total population. The difficulty of the process is that if we started by determining G_m for the male tail, and sought the Gaussian G_f' fitting the remainder, it is highly probable that G_m and G_m', G_f and G_f' will differ considerably in means, standard deviations and size of populations. We have, therefore, to deduce a sort of average result of the two processes[3]. The labour thus involved may be almost as great as proceeding by the more accurate process of the fundamental nonic already referred to.

[1] *Phil. Trans.* Vol. 185 (1894), A, pp. 71—110.

[2] *Biometrika*, Vol. II, p. 3 and Vol. VI, p. 59; *Tables for Statisticians*, p. xxvi.

[3] Let the constants of the processes involved be as follows:

$$G_f : \bar{f},\ \sigma_f \text{ and } n_f ; \qquad G_m' : \bar{m}',\ \sigma'_m \text{ and } n'_m.$$
$$G_f' : \bar{f}',\ \sigma'_f \text{ and } n'_f ; \qquad G_m : \bar{m},\ \sigma_m \text{ and } n_m.$$

Let the constants of the "average" components be

$$\bar{F},\ \Sigma_F \text{ and } n_F \text{ with } \bar{M},\ \Sigma_M \text{ and } n_M \text{ respectively.}$$

Then we must take:

$$n_F = \tfrac{1}{2}(n_f + n'_f), \qquad n_M = \tfrac{1}{2}(n_m + n'_m) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{(i)},$$

In Diagram III, we give the resolution of Parsons' data for 279 measurements of the maximum diameter of the head resolved by Dr Alice Lee (see *Biometrika*, Vol. x, pp. 209—212), and in Diagram IV the resolution of 393 measurements on our English femora for vertical diameter of left femoral head[1]. These diagrams must be compared with Diagram I, which exhibits Dwight's measurements on bones of known sex. Now the mean of Dwight's whole series (♂ + ♀) is about 47, of Parsons' whole Rothwell series (♂ + ♀) about 47, and of our whole London series (♂ + ♀) 44 mm. for the diameter of the head[2]. The first two series are incompatible, and we have little doubt that it is impossible to extend any rule of sexing from the Dwight data to Parsons' without allowing for the circa 3 mm. of cartilage. But even allowing for this and graduating Dwight's data by Gaussian curves, we see that it is not possible to speak of femurs with heads of 46 to 47 mm. as alone of doubtful sex. If we take $n = 8\,^{\circ}/_{\circ}$ and $m = 25\,^{\circ}/_{\circ}$—surely even then rather broad limits for asserting definite sex and probable sex—we should find that the range of femoral heads from about 45·4 to 48·3 was incapable of giving any information as to sex, and that the range of 48·3 to 50·4 was only of *probable* male and that of 43·5 to 45·4 only of *probable* female character. We do not think anything more definite could be deduced from Dwight's data. In round numbers and deducting about 3 mm. for cartilage, etc., we should have for *dry* bones:

< 40·5 ♀	> 47·5 ♂
40·5—42·5 ♀?	47·5—45·5 ♂?
42·5—45·5 ♂.	

This sexing would by no means fit with Dwight's or Parsons' own rules, but it seems to us as much as we can properly venture upon. We have next to ask what similar rules follow from the Rothwell and our London data treated in a like manner. The best we can do for Parsons' data (see Diagram III) on the same $8\,^{\circ}/_{\circ}$ and $25\,^{\circ}/_{\circ}$ basis is approximately:

< 44·5 ♀	> 49·5 ♂
44·5—46·0 ♀?	49·5—48·0 ♂?
46·0—48·0 ♂.	

$$\bar{F} = \frac{n_f \bar{f} + n'_f \bar{f}'}{n_f + n'_f}, \qquad \bar{M} = \frac{n_m \bar{m} + n'_m \bar{m}'}{n_m + n'_m} \quad \text{.....(ii),}$$

$$\left.\begin{aligned} \Sigma^2_F &= \frac{n_f \sigma_f^2 + n'_f \sigma'^2_f}{n_f + n'_f} + \frac{n_f n'_f}{(n_f + n'_f)^2}(\bar{f} - \bar{f}')^2 \\ \Sigma^2_M &= \frac{n_m \sigma_m^2 + n'_m \sigma'^2_m}{n_m + n'_m} + \frac{n_m n'_m}{(n_m + n'_m)^2}(\bar{m} - \bar{m}')^2 \end{aligned}\right\} \quad \text{.....(iii).}$$

(i) insures that the total populations dealt with are the same; (ii) that the mean value of the total remains the same, and (iii) that the second moment of the total is the same as that of the two components.

[1] See also a paper by Pearson on Osteometric Sexing in *Biometrika*, Vol. x, Part iv.

[2] Differences introduced by considering R. and L. members, and by dealing with horizontal, vertical or maximum diameters are of a lower order of magnitude, and do not explain the deviations between the three series.

DIAGRAM III. Parsons' Data. Maximum Diameter of Head of Femur. Anatomical Sexing.

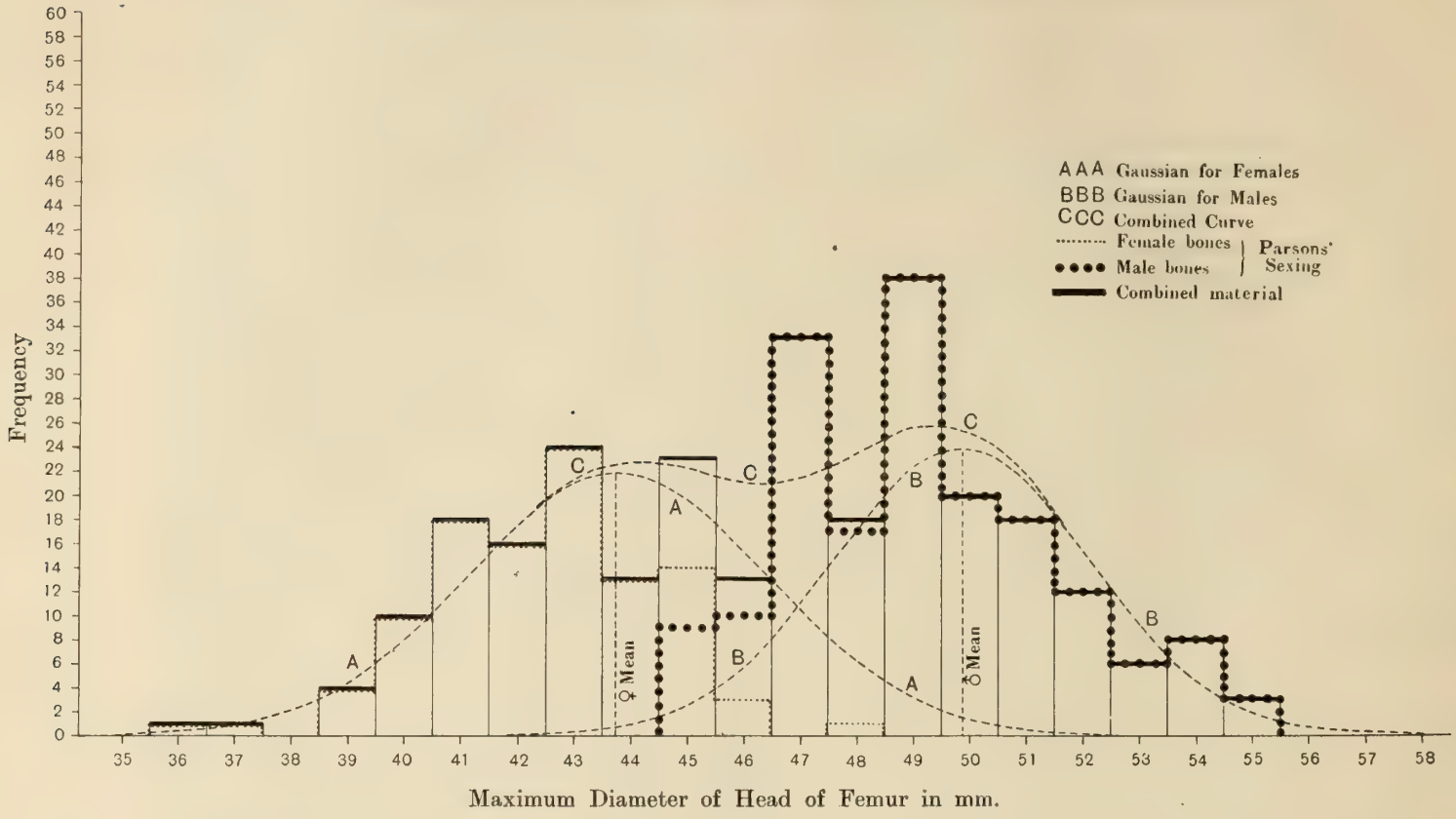
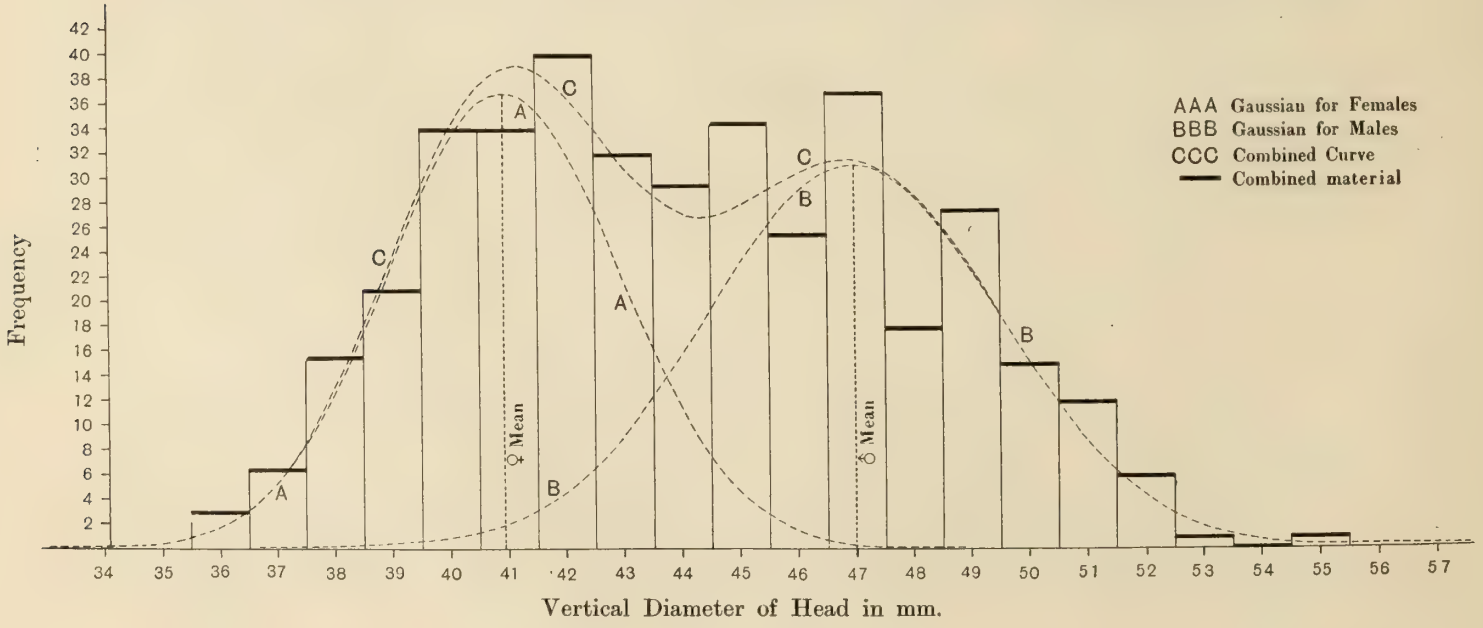


DIAGRAM IV. London Seventeenth Century Femora. Vertical Diameter of Head. Mathematical Sexing.



The heavy and slender dotted histograms give Parsons' sexing and indicate very considerable divergence from the Gaussian curves and a somewhat singular preference for odd readings. We object strongly, having regard to the graduated frequencies, to the cutting off of all ♀'s at 46!

Turning to the London data for femoral head in Diagram IV, we find on the same rough basis:

$< 41{\cdot}5$ ♀	$> 45{\cdot}5$ ♂
41·5—43·5 ♀?	45·5—44·5 ♂?
43·5—44·5 ♂.	

These results while not wholly discordant with those for Dwight's data are inconsistent with those for Parsons' data, and we must conclude that any sexing by size, even of the femoral head, must be based on the individual series under consideration, and cannot be transferred from one race or mixture of races to a second.

We now turn to Diagram II, giving the oblique length of the femur from Hrdlicka's measurements. Here if we adopt the same values for n and m, we find roughly that femora over 47·5 cms. are to be classed as ♂, femora from 45·3 to 47·5 as ♂?, while femora from 40·7 cms. to 45·3 cms. are to be considered as ♂, or unsexable from the oblique length. Below 40·7 cms. the class ♀?, probably female, begins, but we do not get down to the 8 °/₀ limit till 36·8 cms., and the statement that femora $< 36{\cdot}8$ cms. are definitely female would be of small service[1]. It is this last fact which renders sexing from femoral length of less value than sexing from the femoral head. We will consider whether any other lengths give a more definite category of ♀. We take first the trochanteric oblique length. The curves of resolution are given in Diagram V for 355 left bones, and in round numbers we have in cms.:

$< 39{\cdot}0$ ♀	$> 45{\cdot}0$ ♂
39·0—40·5 ♀?	43·0—45·0 ♂?
40·5—43·0 ♂.	

Thus it will be seen on these data that more satisfactory information as to sex may be deduced from the trochanteric oblique length than from the maximum oblique length.

Diagram VI resolves the popliteal length for 404 right bones. It will be seen that this could be taken in nearly fifty more cases than the trochanteric oblique length. There is a redundancy of female bones in the case of the trochanteric oblique length, but there is a greater redundancy here. Further, the average values—♀ 11·02 cms. and ♂ 12·87 cms.—differ somewhat markedly from the values 11·20 cms. and 12·12 cms. found from the anatomical sexing. We attribute this to the marked lumping up of extreme popliteal lengths, possibly a result of random sampling or a result of difficulties in determining the "apex" (or true point of divergence of the internal and external supra-condylar lines) in

[1] These numbers are from rough dichotomies, and in two cases differ from those on p. 46 by a millimetre and a half-millimetre.

DIAGRAM V. London Seventeenth Century Femora. Trochanteric Oblique Length. Mathematical Sexing.

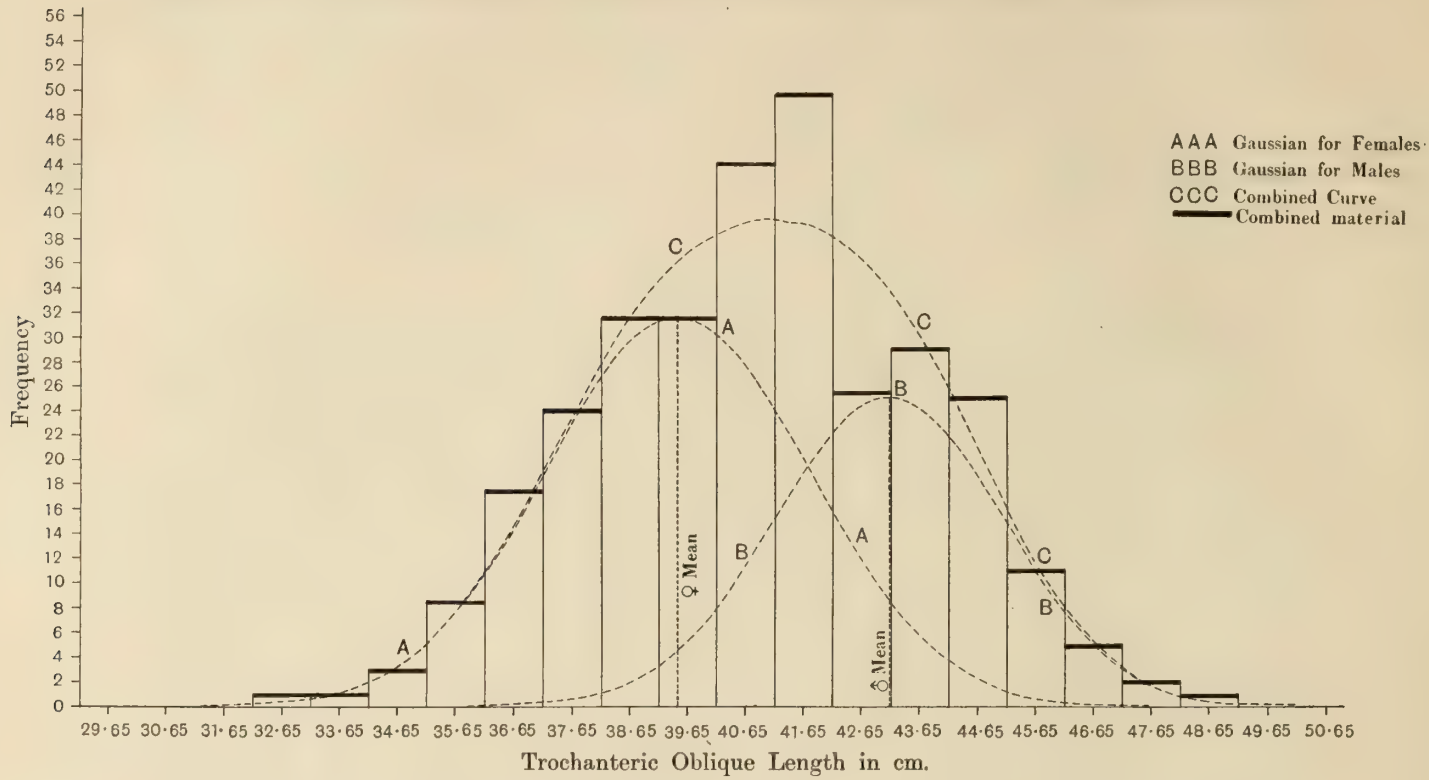
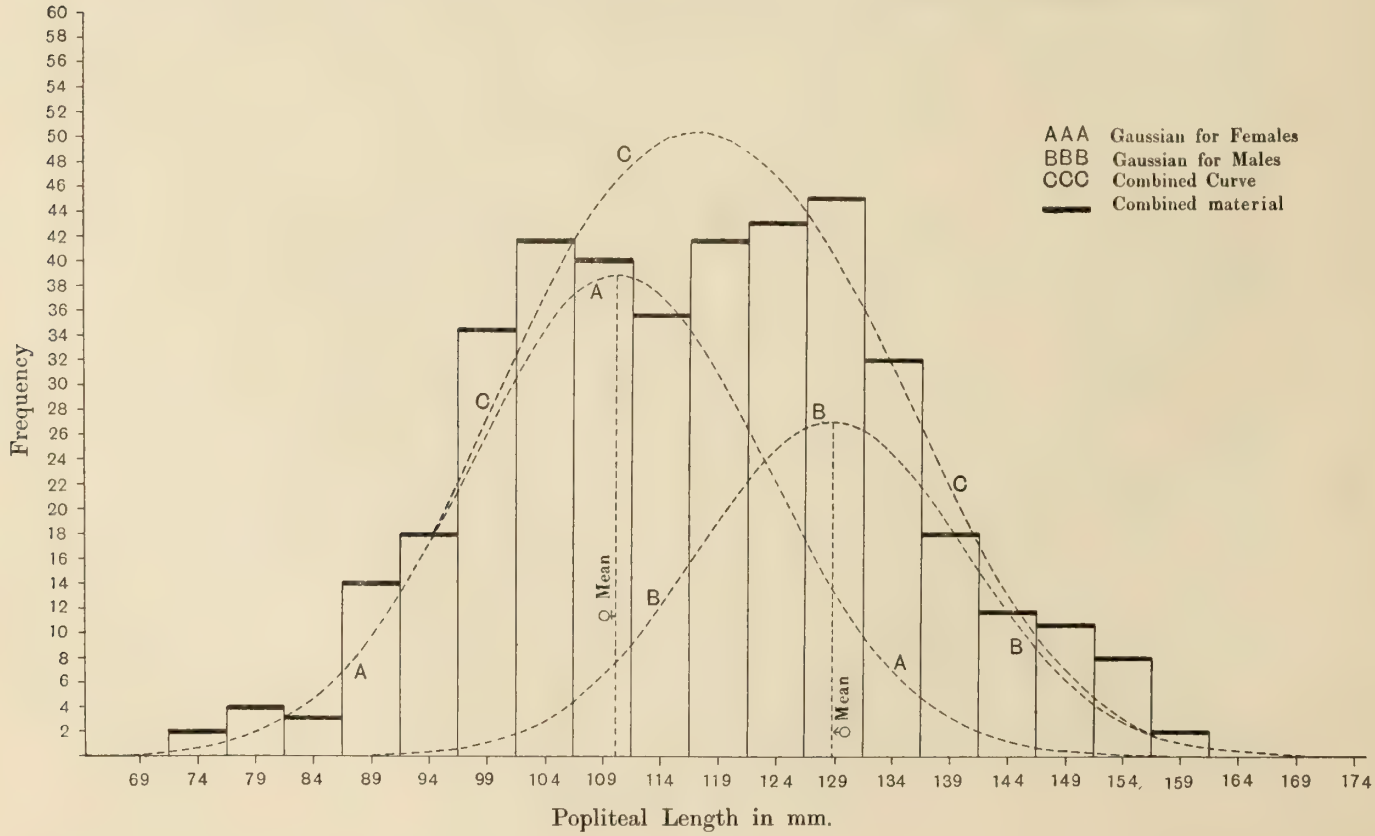

AAA Gaussian for Females
BBB Gaussian for Males
CCC Combined Curve
Combined material
Frequency
♀ Mean
♂ Mean
29·65 30·65 31·65 32·65 33·65 34·65 35·65 36·65 37·65 38·65 39·65 40·65 41·65 42·65 43·65 44·65 45·65 46·65 47·65 48·65 49·65 50·65
Trochanteric Oblique Length in cm.

DIAGRAM VI. London Seventeenth Century Femora. Popliteal Length. Mathematical Sexing.

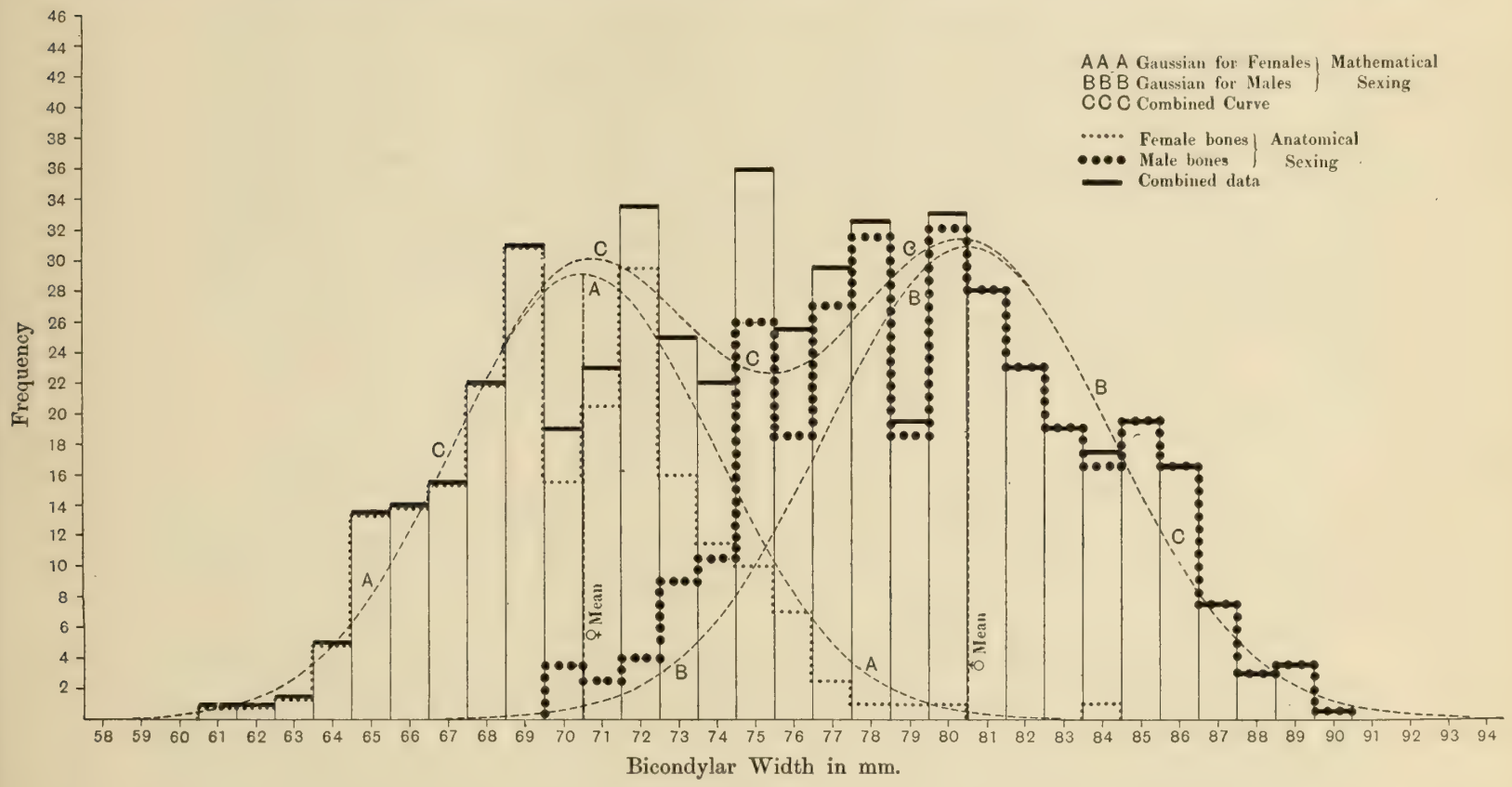

AAA Gaussian for Females
BBB Gaussian for Males
CCC Combined Curve
Combined material
Frequency
♀ Mean
♂ Mean
69 74 79 84 89 94 99 104 109 114 119 124 129 134 139 144 149 154 159 164 169 174
Popliteal Length in mm.

extreme cases. The result of this lumping up has been to reduce the male Gaussian component and raise its mean. Nevertheless, we hold that the sexing on the popliteal length may be of some value as complementary to the trochanteric oblique length, for it gives a more definite group of highly probable female bones, and we do not believe this is wholly due to the over-large reduction in the male contingent just referred to.

The sexing scheme from the popliteal length would run as follows in cms.:

$< 10{\cdot}60$ ♀	$> 14{\cdot}50$ ♂
$10{\cdot}60$—$11{\cdot}45$ ♀?	$13{\cdot}20$—$14{\cdot}50$ ♂?
$11{\cdot}45$—$13{\cdot}20$ ♂.	

DIAGRAM VII. London Seventeenth Century Femora. Bicondylar Width. Comparison of Mathematical and Anatomical Sexing.



As a last illustration we take the bicondylar width. This is given in Diagram VII (see *Biometrika*, Vol. x, p. 485) and leads to the sexing scheme given below. We have taken R. and L. bones together and worked out the resolution for the whole material, youthful bones excluded. The result is surprisingly good. We are inclined to think (see Diagram VII) that bicondylar width is a better sexual character than diameter of head. The separation of the means is almost three times the standard deviation of either and the dip in the combined curve very prominent. We

regret that R. and L. bones were not combined to give the smoother results of larger numbers in other cases. There is reasonable agreement with the histograms for anatomical sexing with the Gaussian curves, 6 °/₀ of bones being the measure of disagreement. In round numbers

<72 ♀	>78 ♂
72—74 ♀?	76—78 ♂?

74—76 ♂.

Besides the above characters, the horizontal diameter of the head was taken, the maximum length, the oblique length, maximum trochanteric length, and the sub-trochanteric antero-posterior and transverse diameters; in most cases right and left bones were taken. In all some sixteen nonics were determined and resolutions discussed. In a number of these cases we admit failure to deduce a sexing scheme of any value. The ♂ and ♀ means determined were too close in relation to the values of the standard deviations to obtain satisfactory numerical appreciation of sex categories. When the male and female populations are not widely unequal, then the distance from male to female mean should be something like twice the standard deviation of one or other sex to get any useful results. But there is another feature making for irregularity in the results: in dealing with the resolution for any character we avoided all appeal to pathological knowledge. We took the bones as measured, and did not differentiate between the Moorfields

Table of Mean Values for each Sex found by "Mathematical" and "Anatomical" Sexing.

Character of Femur	Male				Female			
	Right		Left		Right		Left	
	Mathematical	Anatomical	Mathematical	Anatomical	Mathematical	Anatomical	Mathematical	Anatomical
Diameter of Head (vertical)	46·8 mm.	47·1 mm.	47·0 mm.	46·8 mm.	40·9 mm.	41·1 mm.	40·9 mm.	40·8 mm.
Diameter of Head (horizontal)	46·2 mm.	46·6 mm.	46·2 mm.	46·4 mm.	40·1 mm.	40·7 mm.	40·3 mm.	40·5 mm.
Popliteal Length	12·9 cm.	12·1 cm.	—	—	11·0 cm.	11·2 cm.	—	—
Bicondylar Width	80·5 mm.[1]	80·1 mm.	80·5 mm.[1]	79·4 mm.	70·5 mm.[1]	70·1 mm.	70·5 mm.[1]	69·9 mm.
Maximum Length	43·8 cm.	44·8 cm.	—	—	40·4 cm.	41·0 cm.	—	—
Trochanteric Oblique Length	43·1 cm.	42·4 cm.	43·7 cm.	42·3 cm.	39·5 cm.	38·6 cm.	39·8 cm.	38·6 cm.
Maximum Trochanteric Length	44·0 cm.	43·5 cm.	—	—	40·4 cm.	39·8 cm.	—	—

[1] R. and L. bones were taken together for the mathematical reduction.

and Whitechapel material, further we did not discard obviously pathological conditions (*e.g.* rachitis). The result is that in certain series of measurements—for example, the maximum length—there were "tails" which considerably influenced the higher moments, and so the resolutions. To these irregularities, the relatively few bones used for each character also contributed. Thus the total number of bones classed as ♂ and ♀ varied considerably from character to character, and the standard deviations as determined from "mathematical" and "anatomical" sexing were not always closely in accordance. The accompanying tables indicate the amount of agreement obtained. We have inserted the diameters of the head, the popliteal length, the bicondylar width and the trochanteric oblique length which have been used for sexing, and also the maximum length and maximum trochanteric length, which were rejected for this purpose.

The table on p. 54 brings out a fairly comforting degree of accordance in the means deduced by the two methods. It has been used merely as a confirmation of the results of sexing by general anatomical appreciation. The next table gives the variabilities for each sex in the case of a few characters. The agreement is not unimpeachable, but considering the relative smallness of our numbers, not so unsatisfactory. At any rate it gave us more confidence in sexing by general anatomical appreciation, than the very guarded opinion of several anatomists had previously permitted us to possess.

We next investigated the degree of coincidence, not between constants of the distribution, but in the sexing of the individual bones as based upon the anatomical

Table for Standard Deviations of each Sex found by "Mathematical" and "Anatomical" Sexing.

Character of Femur	Male				Female			
	Right		Left		Right		Left	
	Mathematical	Anatomical	Mathematical	Anatomical	Mathematical	Anatomical	Mathematical	Anatomical
Diameter of Head (vertical)	3·01 mm.	2·89 mm.	2·61 mm.	2·80 mm.	1·88 mm.	2·08 mm.	2·05 mm.	2·00 mm
Diameter of Head (horizontal)	2·99 mm.	2·83 mm.	2·77 mm.	2·60 mm.	1·56 mm.	2·04 mm.	1·52 mm.	1·99 mm.
Popliteal Length	1·15 cm.	1·69 cm.	—	—	1·27 cm.	1·50 cm.	—	—
Bicondylar Width	3·69 mm.[1]	4·03 mm.	3·69 mm.[1]	4·11 mm.	3·48 mm.[1]	3·39 mm.	3·48 mm.[1]	3·46 mm.
Maximum Length	2·49 cm.	2·23 cm.	—	—	2·15 cm.	2·01 cm.	—	—
Trochanteric Oblique Length	2·01 cm.	2·06 cm.	1·94 cm.	2·15 cm.	2·31 cm.	1·93 cm.	2·46 cm.	1·95 cm.
Maximum Trochanteric Length	2·25 cm.	2·09 cm.	—	—	1·90 cm.	1·91 cm.	—	—

[1] R. and L. bones were taken together for the mathematical reduction.

appreciation and upon four chosen characters: Vertical Diameter of Head, Popliteal Length, Bicondylar Width, and Trochanteric Oblique Length. The "mathematical rules" for sexing by these characters are given above and collected here again. We must beg the reader to note that they cannot be applied to other material, for the sexual differences are often less than racial differences. They must be deduced afresh for each new series[1]. We have chosen the above four characters

Rules for "Mathematical" Sexing.

Character	♀	♀?	♂	♂?	♂	Mean of unsexed material	
						R.	L.
Vertical Diameter of Head.....	< 41·5	41·5—43·5	43·5—44·5	44·5—45·5	> 45·5	44·55	44·08
Popliteal Length	< 106	106—114·5	114·5—132	132—145	> 145	117·4	—
Bicondylar Width	< 72	72—74	74—76	76—78	> 78	75·82	
Trochanteric Oblique Length...	< 390	390—405	405—430	430—450	> 450	409·2	408·0

Mathematical and Anatomical Sexing in the case of 80 *bones*[2].

Math.	Anat.	Math.	Anat.	Math.	Anat.	Math.	Anat.	Math.	Anat.
♀(+2)	♂?	♂(−3)	♂	♂(−2)	♂	♀(+4)	♀	♂(0)	♀?
♂?(−1)	♂	♂(−6)	♂	♂(−3)	♂	♂(−5)	♂	♀(+8)	♀?
♀(+3)	♂	♂(−4)	♂?	♂(0)	♀	♀(+8)	♀	♀(+4)	♀
♀(+5)	♂?	♀?(+1)	♂	♂(−2)	♂	♀(+2)	♀	♀(+2)	♀
♂(0)	♂?	♂(−5)	♂	♀(+2)	♀	♂(−2)	♂	♀(+3)	♀
♀(+6)	♀	♂(−8)	♂	♀?(+1)	♀?	♀(+8)	♀	♀?(+1)	♂
♀(+4)	♀	♂(−2)	♂	♂(−4)	♂	♀(+6)	♀	♀(+3)	♂
♂(−4)	♂	♀(+4)	♀?	♀(+3)	♂?	♀?(+1)	♂	♂(−5)	♂
♀(+2)	♂?	♀(+6)	♀	♂(0)	♂	♀(+5)	♀	♀?(+1)	♀
♀(+6)	♀?	♂(−4)	♂	♂(−4)	♂	♂(−7)	♂	♀(+3)	♀
♂(0)	♂	♂(−7)	♂	♂(−2)	♂	♂(−6)	♂	♀(+6)	♀
♂?(−1)	♂	♂(−4)	♂	♀(+2)	♀	♀(+6)	♀	♀(+8)	♀
♀(+3)	♀?	♀(+6)	♀	♀(+7)	♀	♀(+5)	♀?	♂(−5)	♂
♀(+5)	♀	♂(0)	♂	♀(+4)	♂	♂(−3)	♂	♀?(+1)	♂?
♀(+2)	♀	♂(−4)	♂	♀(+2)	♂?	♀(+5)	♀	♀(+4)	♀?
♀(+6)	♀	♂?(−1)	♂	♀(+7)	♀	♀(+5)	♀	♂?(−1)	♂
♂(−2)	♂	♂(−2)	♂	♂(0)	♂?	♂(−5)	♂	♂(−3)	♂?
♂(−2)	♂	♀(+3)	♀	♂(−7)	♂	♀?(+1)	♂	♂(−3)	♂
♂(−2)	♂	♀?(+1)	♀	♂(0)	♂	♂(−5)	♂	♂(−6)	♂
♀(+3)	♀	♂(−5)	♂	♀(+4)	♀	♀(+6)	♂?	♀(+7)	♀

[1] Bearing in mind that the means and standard deviations change from race to race, we see that only a rough appreciation of the sexual categories for one race can be deduced from those for another by altering the limits of the sexual classes for each character in the ratio of the means of the unsexed material for the two races.

[2] Bones falling on either boundary of the categories ♀? and ♂? have been taken to belong to that category.

because they seemed in the present case to provide the best sexual differentia from among the sixteen cases we analysed. None of the angles seemed suggestive of marked sexual difference; the question of the indices will be dealt with later.

The table on p. 56 gives the sexing of 100 bones from our measurement tables by the above scheme, the quantitative degree of the "mathematical" sexing as well as the anatomical judgment being provided. Each tenth bone was taken, if not too broken, to give two significant measurements at least out of the four selected as criteria.

The following table contains a concise analysis of the above 100 femora:

Mathematical Sexing	Anatomical Sexing ♀	♀?	♂?	♂	Totals
♀	30	7	—	5	3	45
♀?	—	3	—	1	4	8
♂	1	1	—	2	4	8
♂?	—	—	—	—	4	4
♂	—	—	1	2	32	35
Totals	31	11	1	10	47	100

The high degree of correlation[1] is at once obvious. Out of 42 bones classed by Dr Derry as ♀ or ♀? not a single one by the mathematical method was classed as male; on two the mathematician expressed no opinion, and of the 10 remaining anatomical ♀?s, he agreed with Dr Derry in three cases and made the remaining 7 definitely female. It may thus be said that the mathematical method will give as female practically all the bones the anatomist treats as female. Turning to the male bones the results are not in such good accord. Of the 57 femora sexed as male or doubtful male by Dr Derry, the mathematical method failed to give sex in six cases. Of the remaining 51 bones 38 were sexed as male or doubtful male also by the mathematician. The last 13 bones were classed anatomically as 6 ♂? and 7 ♂. Of the former group one was called ♀? by the mathematician and 5 ♀; of the latter group of anatomically definite males 3 by

[1] If we make a fourfold table between mathematical and anatomical males and females, halving the ♂'s—and this is justifiable in that not sex, but our appreciation of it is a quantitatively measurable character which ranges from certitude of male to certitude of female—we find

$$\text{tetrachoric } r = -\cdot 920 \pm \cdot 028,$$

a high degree of relationship. We feel certain that such a correlation would not have been reached had not both anatomical and mathematical judgments been based on a considerable range of characters, and would no doubt have been bettered had that range in both cases been increased.

the mathematical method were given as definitely female and 4 as doubtfully female. If we judge by mere size proportions of the bone, the judgment of the mathematician made on the actual measurements of the bones must be more correct than any anatomical appreciation of unmeasured size; but the anatomist judges largely by muscular appearance, and as no weight has been given by the mathematician to this important character, it is clear that the anatomist has here the advantage. This would cease if we included in our list of criteria some measure of muscularity. No such measure has at present been taken, but it does not seem impossible, and it would undoubtedly render more perfect the mathematical method. Even as that method stands—without the developments and improvements of which it seems capable—it may well be that two anatomists will give sex determinations which differ more from each other than either do from the mathematical determination.

But our main object in the present investigation has not been to replace anatomical appreciation by a mathematical method, but to ascertain how far anatomical sexing gave results which in the main could be confirmed by other processes. We consider that substantial confirmation has been obtained mathematically for Dr Derry's sexing on general anatomical grounds[1]. We do not consider that Parsons' appeal to Dwight's results is adequate, the sexing from the actual measurements must be of a far more thorough nature and can only be undertaken by a trained statistician. A striking instance of the same incapacity to appreciate the methods of statistical science is evidenced in Parsons' second

[1] The agreement is really far greater than appears from the above merely numerical analysis. In nearly every case of the thirteen in which there was real disagreement there was small weight of mathematical evidence. Thus W. 10, given mathematically as + 2 or ♀ and anatomically as ♂?, is a judgment based only on the popliteal length (104), the bicondylar width fails and the trochanteric oblique length and the vertical diameter of the head fall into the neutral area; the popliteal length, however, is essentially female. In W. 30, given anatomically as male and mathematically as + 3 or ♀, the trochanteric oblique length (379) and the popliteal length (105) are such as occur only in female bones, the bicondylar width (75) is neutral, and solely the head of the femur (45) points to doubtful maleness. In W. 40, which the anatomist makes ♂? as against the mathematical + 5 or ♀, the trochanteric oblique length is neutral, the head of the femur (42) is small and marks ♀?, while the popliteal length (104) and the bicondylar width (70) are essentially female in character. In W. 200, which is anatomically classed as ♂ and mathematically + 1 or ♀?, the trochanteric oblique length (381·5) is markedly female, but the head of the femur (46) is essentially male, the bicondylar width is neutral, which leaves the matter to be settled mathematically by the popliteal width of 112·5, which lies on the female side or is ♀?. Again in the case of W. 460, which is anatomically male, every one of the four characters used as criteria falls on the female side of the neutral region, and the bone is mathematically + 4 ♀. And so we could go through the whole series of differences; in all thirteen cases either the evidence for sexing is weak, or there is in one or more of the criteria a position of the bone which judged from our diagrams it would be very difficult to accept and give it other than the mathematical sex. In other words, where the mathematical differs essentially from the anatomical judgment there the sex has either been based on very slender evidence and the contradiction is more apparent than real, or there the sex is based on such very strong evidence that we are inclined to believe that the anatomical judgment would have been modified by a knowledge of the actual measurements.

paper on the English Thigh-Bone[1]. *Nothing whatever can be judged by dotted charts of frequencies when one series contains only twenty-five individuals!* In some of Parsons' distributions the maximum group or a group equal to the maximum actually occurs at or almost at the tail of the distribution, and in no case has he made any attempt to replace his slender distributions by smoothed frequency curves in order to determine how much greater would have been his "overlaps" had he replaced his extremely small samples by the indefinitely large populations from which he has sampled. It is needless to say that the range of variation cannot be appreciated graphically, but only numerically, and then but roughly, from such small samples. We can give therefore no further weight to his new rules for sexes than to his former ones. If sexing is to be deduced from *measurement*, and not from general anatomical appreciation, then the investigator must understand once and for all that statistics is as definite a science as anatomy and requires a knowledge of its laws before it can be used effectively.

In this chapter we have chiefly defended general anatomical appreciation of sex in long bones on the agreement it gives with mathematical sexing, but it is possible to show in other ways its effective character.

As a suitable illustration we may note the degree of accordance between three separate sexings of some of the Naqada femora. Dr Warren first sexed these long bones largely on the basis of the corresponding pelves, and where these failed by using the first sexing of the corresponding crania; an independent sexing of the crania was later made afresh for the purpose of Fawcett's paper on the Naqada crania. Lastly a third sexing was made on the femora solely as they were handled in Cambridge recently by one of the present authors on general anatomical grounds and after considerable experience of the sexing in the case of the London femora. We shall speak of these three sexings of the same bones for brevity as the pelvic sexing, the cranial sexing, and the general anatomical sexing. These sexings are compared in the tables on p. 60[2]:

It will be seen that the correlations between the three methods of sexing are very high indeed, and that the judgment of sex in the case of 102 skeletons (102 crania and 204 femora) only differed absolutely in 2 cases, the remaining 11 cases being ♂? in the case of one sexer or ♀? in the case of the other. The general accordance is very good and, just as the mathematical sexing, it should

[1] Bibl. 114. On pp. 347 and 359 discredit is again cast on Pearson's formula for the stature as deduced from the maximum length of femur by Parsons' erroneous use of the *male* reconstruction formula to find a female stature! Actually Pearson's ♀ formula gives 153·8 cms. for the Rothwell females and not 160 as Parsons states, which compares well with the London dissecting-room population (14 ♀s only!), of which the length, presumably the corpse length, is stated to be 154·9 cms. Deduced from their measured femur lengths these corpses should have had a mean stature of 153·6 cms., almost exactly the Rothwell value.

[2] The relatively small numbers in these tables arise from the non-coincidence of the series dealt with. Not every skeleton had both cranium and femora; many femora cannot now be identified with either Warren's numbers or the cranial numbers and others have perished owing to their condition.

Pelvic Sexing

Cranial Sexing	♂	♀	Totals
♂	66	13	79
♀	5	96	101
Totals	71	109	180

$r = \cdot 956$

No queried sex was given in the pelvic sexing, but in the cranial sexing 8 of the 13 group were given as ♂?, and 1 of the 5 group as ♀?.

Pelvic Sexing

General Anatomical Sexing	♂	♀	Totals
♂	98	16	114
♀	6	96	102
Totals	104	112	216

$r = \cdot 956$

No queried sex was given in the pelvic sexing, but in the general anatomical sexing 11 of the 16 and 3 of the 6 groups were given respectively as ♂? and ♀?.

Cranial Sexing[1]

General Anatomical Sexing	♂	♀	Totals
♂	42	7	49
♀	6	47	53
Totals	48	54	102

$r = \cdot 921$

Of the group of 7, 2 were unqueried in both cranial and anatomical sexing, 2 were queried by one or other sexing and the remaining 3 were queried by both. Of the group of 6, 4 were queried by one or other sexing and the remaining 2 were queried by both.

tend to give confidence in sexing based on general anatomical appreciation as distinguished from a mixed method, which pays attention only to the size of an isolated character or two.

The chief conclusions that we have drawn from our mathematical investigations, of which only a small portion is indicated in this chapter, are:

(i) That confidence may really be placed in a sexing of the long bones based not on one or two individual characters, but on a general anatomical appreciation.

(ii) That it is possible, but laborious, to deduce mathematical rules for sexing, but that for each series of bones they can certainly be found and that the advantage of this method is great, for it gives us a quantitative measure of the reliability of our judgment of sex.

[1] In these tables the use of the tetrachoric method can be defended as before; we are correlating not opposed categories, but continuous variates, our convictions as to the sex of the bone, which actually range from practical certainty of maleness through every shade of doubt to practical certainty of femaleness.

(iii) That methods like those suggested by Dwight and Parsons are quite unreliable having regard to our present knowledge of statistical and osteometric theory.

And lastly:

(iv) That the general anatomical appreciation and the mathematical judgment of sex will practically be in reasonable accord, if based on adequate considerations in both cases.

In recording the sex of the femur in the present memoir we have tabled according to the general anatomical appreciation of sex, but in the case of some of the other long bones we have relied in the first place on the mathematical sexing and used the anatomical only as a secondary criterion in case of doubt.

CHAPTER III

ON THE CHIEF ANOMALIES OF THE FEMUR

The registration of anomalies is of very great interest from three different standpoints:

(*a*) The proportion of the various anomalies occurring in a given bone may have racial significance and so enable us to form a racial scale. This scale may be of interest either as bearing on racial habit, if we suppose these characters due to habits or occupations, or on the other hand as bearing upon the evolutionary history of man, if we compare the frequency exhibited in our racial scale with that of the corresponding frequencies in other types of life.

(*b*) If we assume that certain appearances or characters are due to habit or use, we should be able from a careful examination of a bone to predict something of the life-history of its former owner. This conception, it must be admitted, is in the highest degree fascinating, but we must not allow that very fascination to carry us beyond the limits of scientific logic, and lead us, as some investigators have been led, to discover in the characteristics of a bone a graven record of the life of the individual of whom it once formed a part. When we find that practice develops muscle, when we find that great muscularity is associated with differential signs of muscular attachment, it may seem reasonable to suppose that the occurrence of these signs marks an individual who has exercised his limbs in a particular manner. But it may equally well be that these differential signs are a needful antecedent of the capacity for developing muscle, and that their presence is not necessarily a sign of habit. We may find them not only in the very muscular male, but in the female and the infant, and in cases where no strenuous occupation could possibly have called them into existence. It is highly dangerous again to conclude from markings on bones which belong to a race, which practises certain postures, that the markings are due to the postures, for we may later discover them in infants of the same race—and thus our first dogma drive us to a second, that of the inheritance of acquired characters—or again in adults of another race who have never adopted the postures. In which case a third dogma, that of the existence of the atavistic acquired character, is requisite.

(*c*) A record of the characteristics referred to may further be of great interest, if we have convinced ourselves that they are in the main congenital and hereditary. Studied in connection with their appearance in other types of life, where they

may still be of obvious service, they may help us to confirm the idea of a common ancestry for living forms, and may even throw light on the actual pedigree. Probably more would have been achieved in this direction had the biologist rather than the practical anatomist been first in the field.

The following are the chief anomalous characters of the femur, which we have endeavoured to record; we have included under each some account of the history of its study.

(i) *The Third Trochanter.* (See Plates XXVIII and XXIX.) The use of this term for an apophysis in the posterior subtrochanteric region and generally immediately below the great trochanter is we believe due to Cuvier. In the edition of the *Leçons d'Anatomie comparée* of 1805, Tom. I, p. 353[1], Cuvier refers to an "apophyse en forme de crochet" which appears on the femur of tapir, rhinoceros, horse, armadillo and beaver, but he does not call it a third trochanter. In the edition of the same work in 1835, after Cuvier's death, we are told by the editors (Laurillard and F. Cuvier) that in the loris and lemurs there is a projection at the basis of the great trochanter which may be considered a vestige of the third trochanter which is found in the mole, the chrysochlore and several other mammals (Tom. I, p. 491). On p. 493 in a passage which was apparently inserted by Cuvier himself[2] we are told in the case of the beaver that:

le fémur large, aplati d'avant en arrière, a, à son bord externe, une crête tranchante qui tient lieu de ligne âpre et qui se prolonge vers son milieu en une apophyse à laquelle on donne le nom de *troisième trochanter.*

Cuvier then refers to forms of it in rodents—musk-rats, hares, rats—where it takes the form of a ridge or *crest*, and then to the rhinoceros, armadillo (where it is very large) horse, etc. The Editors on p. 501 state that the great gluteal muscle descends in armadillos and anteaters to the third trochanter and that this gives it great grip; the same muscle is attached to the third trochanter in the case of the horse. It will be seen that by the time of Cuvier's second edition of the *Anatomie comparée*, the term was in use, it was recognised as an area of attachment for the great gluteal muscle, and the "nipple" and "crest" forms were distinguished.

It is less easy to determine, who *first* drew attention to the existence of an occasional third trochanter in man. Cruveilhier in 1834[3] realised the occasional existence of the apophysis in man:

La ligne âpre, plus inégale en haut qu'en bas se bifurque à ses deux extrémités. Des deux branches de la bifurcation supérieure, l'externe, extrêmement rugueuse, est quelquefois surmontée d'une éminence assez considérable [qui représente une espèce de petit trochanter—addition in later editions] et va se continuer jusqu'à l'apophyse volumineuse qu'on appelle grand trochanter (p. 275).

[1] Bibl. 1.

[2] Cuvier had prepared, but left incomplete at the time of his death, this second edition. A suggestion we have met with that Cuvier first used the term "third trochanter" in describing the femur of *Equus asinus* we have been unable to verify.

[3] Bibl. 2.

Wilbrand in 1843 and Barkow in 1851 had mentioned a process relatively low in the femur and compared it with the third trochanter in the horse, tapir, beaver, etc. But it is doubtful whether this process is a true human third trochanter. We shall return to the point later, when dealing with the *Processus supracondyloideus.*

Humphry writing in 1858[1] says:

> A rough prominent surface for the attachment of the tendon of the *gluteus maximus*—the great opponent of the *psoas* and *iliacus*—is situated a little external to the trochanter minor and runs for some distance down the hinder and out part of the shaft.

To this paragraph he attaches the footnote:

> The space for the attachment of the *gluteus maximus* runs out into a broad bold process in the hare and some other animals....

Clearly he had the third trochanter in mind, but the passage is obscure, and it might read as if the human third trochanter always existed as the point of attachment for the tendon of the great gluteal muscle, instead of being anomalous in man. Thus while Cruveilhier remarked the anomalous occurrence of the process in man, he does not directly associate it with the third trochanter of other mammals; Humphry recognising the association says nothing about the merely occasional appearance in man. Finally in 1878 Luther Holden in a student's text-book of anatomy, which lays no claim to scientific research, remarks[2]:

> Take the *outer* lip first. The "vastus externus" arises from it three-quarters of the way down. Along the upper third is a very rough surface for the insertion of the gluteus maximus. This part may very properly be called the "gluteal ridge," it is sometimes so prominent as to resemble the third trochanter of animals (p. 196).

Here the anomalous character and the association with the third trochanter are both emphasised and as far as we can discover for the first time. Yet it is quite probable that Cruveilhier and Humphry had exactly these points in mind, but failed to give due expression to them. Indeed it is almost certain that Dupont in 1867[3] was dealing with the third trochanter in man, for after referring to an apophysis in the usual position of the third trochanter in the human femora, he terms these processes *epitrochanters* "according to the expression of Pruner Bey." We have not been able to verify Pruner Bey's use of the word, but the fact that Pruner Bey and Dupont used a misleading term for the third trochanter in man, calling it an "epitrochanter" when "hypotrochanter" would have been better, does not deprive them of the merit of being among the first to observe this apophysis in man.

Two years after Luther Holden, Waldeyer[4], who was acquainted with the books of both Humphry and Holden, published the first special paper dealing with the third trochanter in man and emphasising its relation to that of certain mammals. His paper is chiefly historical, but has some sparse statistics of the frequency in man—

[1] Bibl. 5.

[2] Bibl. 17. It must be remembered that previous to 1880 none of the big text-books of anatomy, Sappey, Heule, Quain or Krause, had referred to this third trochanter in man.

[3] Bibl. 13.

[4] Bibl. 25.

the earliest we have come across. From the standpoint of comparative anatomy Waldeyer gives little more than could be gleaned from Cuvier, Owen and Flower[1]. He states that the third trochanter exists in many *Insectivora* (for example the hedgehog), *Rodentia* (hare, squirrel, beaver, etc.), in all *Perissodactyla*, with some *Edentata* (armadillo, orycteropus), but is wanting in the *Artiodactyla*. In this latter statement Waldeyer probably followed Flower who says it is entirely absent in known *Artiodactyla*[2]. But Houzé, who made a very careful examination of all the bones available in the Brussels Museum, found it among the ruminants in a rudimentary state and also in the hippopotamus[3]. Waldeyer does not refer to the existence of the third trochanter on certain fossil mammals as on the Typotherium (Bravard) or as it is sometimes called the Mesotherium (Serres). He says that the position of the third trochanter varies with the species, it is always in the neighbourhood of the *linea aspera*, but in some close under the trochanter major as in the hare and squirrel, in others as in the beaver a long way down the shaft; it is most voluminous in the horse and rhinoceros, as large as or even larger than the great trochanter.

It will be recognised at once that the third trochanter is a very persistent character the presence or absence of which in species is of essential importance from the standpoints of both evolution and comparative anatomy[4]. It can hardly be explained away in man as the result of muscular development. Waldeyer himself examined twenty-two human skeletons and found seven skeletons to exhibit it, which he calls "over 30 °/₀." We presume that whether it occurs on one or both femora he reckons it a single occurrence. While he found the third trochanter on both sides in a male Turk and a very muscular Piedmontese, he also found it on both sides in the skeleton of an Italian girl aged 18, and on both sides in a non-muscular woman aged 30 from Elsass. It will be seen that Waldeyer like many of those who have followed him dealt with very small numbers, but he drew the general attention of anthropologists to the subject.

(ii) The *Fossa Hypotrochanterica*. (See Plate XXXVI.) Three years after Waldeyer, Houzé[5] published an important contribution to the subject. Besides a reinvestigation of the third trochanter bearing species, to which he added the *Dinornis elephantopus* (Owen), *Artiodactyles*, as already stated, and the *Crocodilidae*, Houzé endeavoured more exactly to define the phenomenon under consideration, and he observed that occasionally running along the line of the gluteal ridge is a trough or depression which frequently concludes towards the basis of the great trochanter in the nipple or crest form of the third trochanter. The borders of this trough serve for insertion of the *gluteus maximus* just like the gluteal ridge itself. Further the bottom of the "trough" is occasionally rugose showing that it also serves for the attachment of the muscle in these cases. To this depression or trough, which can occur,

[1] *Introduction to the Osteology of the Mammalia*, 1st Edn. 1870, 2nd Edn. 1876.

[2] *Ibid*, 3rd Edn. 1885, p. 333. [3] Bibl. 31.

[4] In the *Amblypodes* its presence or absence has been used to characterise the difference between the *Pantodontidae* and the *Dinocerata*. See Pouchet et Beauregard, Bibl. 47, p. 181.

[5] Bibl. 31.

however, without a sensible third trochanter, Houzé gave the name *fossa hypotrochanterica* and since his day these two anomalies have been considered in conjunction. Indeed we ought to say *three* anomalies, for the trochanteric crest or ridge can exist independently of, or together with the third trochanter, and we may have in the same individual a *fossa hypotrochanterica* surmounted by a *crista trochanterica*[1] which concludes with a well-marked *trochanter tertius*. Further these anomalies of the human femora find their parallels in the lower animals. Thus in certain femora we have been able to examine we have found the third trochanter alone, well marked in the tapir, rhinoceros and hare, less marked in Hyrax, and flattened in Dasyprocta and Macropus; there was a *crista trochanterica* rather than a *trochanter tertius* in the femora of gibbons, beavers and most Carnivora while femora of Orycteropus. and Chrysochloridae had both *crista trochanterica* and *trochanter tertius*. Dasypus, which is nearly always cited as an example of *trochanter tertius*, showed also a well-marked *fossa hypotrochanterica*. Costa found a *trochanter tertius* in a specimen of *Hylobates agilis* and also in a chimpanzee; in an orang utan he found both *fossa* and *crista hypotrochanterica*, while in the femur of a gorilla he found only the *fossa*[2]. It is clear that these three anomalies as appearing in man can only be studied in conjunction with comparative material. Further we must insist on the point that there exists a wide range of variation; the crest when it exists alone may pass insensibly into the "nipple" type of third trochanter, and it is almost impossible to assert where either begin or end. What is a normal gluteal ridge, or when is its termination to be regarded as the first sign of a third trochanter? In the same way the *fossa hypotrochanterica* may be well marked or so faint that it can hardly be seen and only be felt with the finger. There is no common standard of what is to be treated as an incipient anomaly in any one of these cases, and it is to the personal equation thus involved that we should attribute the widely different percentages reached by various observers. We hesitate to believe them due to marked racial differences in the bones examined. Of course this criticism would apply in a less degree to different races treated by the same observer, *if studied in adequate numbers*[3], but even then racial differences in form and location, together with weathering of the material, may lead to diversity in appreciating incipient anomalies.

[1] This trochanteric crest must not be confused with the *crista intertrochanterica* or posterior intertrochanteric line. The former is called "crista" by the Italians and a "Leiste" by the Germans.

[2] We have not found this fossa in the gorilla femora examined by us, but we have noticed indications of it in the gibbon, the orang and the chimpanzee. In the latter two cases the conditions are somewhat modified by the presence of a ridge between the *fossa hypotrochanterica* and the helical *fossa angulolateralis*.

[3] None of these writers accompany their results by any appreciation of the probable error of their percentages! Thus Waldeyer found the *trochanter tertius* in 7 out of 22 skeletons, and his 30 °/₀ has been cited as a number which conveys some impression of the frequency of the phenomenon. But actually on the basis of his numbers all we could safely say would be that any percentage between 10 and 50 would not be improbable! Again Houzé only felt able to give the actual sex in the case of 20 femora, 10 modern males and 10 modern females. Of these 20 bones *one* male and *three* female had the third trochanter. These are the only sexed material with which he deals. Now if the *trochanter tertius* were equally probable in male and female, we should from the above results expect *two* cases in

Houzé's statistics are more ample than Waldeyer's, but there is often a cloaking of paucity of numbers under percentages. Consider such a passage as the following: out of 16 negro femora 12 °/₀ had the third trochanter, 6 °/₀ the *fossa hypotrochanterica* and 6 °/₀ the two combined. This seems only to amount to saying that out of sixteen femora two had the third trochanter only, one the *fossa*, and one other combined the *fossa* with a third trochanter! Houzé is strongly of the opinion that primitive man had more frequently than modern man a *fossa hypotrochanterica* on his femur, and as evidence he cites that "all" the femora of the age of the reindeer in Belgium, 60 °/₀ of the femora of Grenelle, associated with the former by Quatrefages, two Cro-magnon femora and a femur of the Madeleine (age of the reindeer) in the Museum at Paris have the *fossa*. He does not tell us how many of the Cro-magnon femora were without it, but concludes that in 44 femora from the quaternary epoch the *fossa* was "very frequent." We do not know whether this number includes all available femora of the period, or is largely built up of the isolated femora he had observed it in, nor finally in how many of the 44 bones it really occurred.

Houzé had at his command one longer series, 110 femora from the polished stone age, and we may hope for more reliable results here. We are told that 38 °/₀ (presumably 42) had the *trochanter tertius*, 20 °/₀ (presumably 22) had the *fossa*, and 24 °/₀ (presumably 26) had the two combined, which is clearly impossible, unless we suppose the previous percentages to refer to those which have the *fossa* and the third trochanter *alone*[1]. Of 67 modern Brussels femora Houzé further tells us that 30·15 °/₀ (presumably 20) had the third trochanter, 10·5 °/₀ (presumably 7) had the *fossa*, and 5 °/₀ combined the two. The latter percentage seems inconsistent with either three or four cases exhibiting the combination. Assuming Houzé to have really had three such femora, we have the following two tables:

Fossa Hypotrochanterica	Polished Stone Age: Third trochanter			Modern Belgians: Third trochanter		
	Present	Absent	Totals	Present	Absent	Totals
Present	26	22	48	3	7	10
Absent	42	20	62	20	37	57
Totals	68	42	110	23	44	67

a sample of 10 bones, and the proper answer would be $2 \pm \cdot 85$ showing that either 1 or 3 occurring in a sample of 10 would mean nothing at all. Yet Albrecht in 1884 in presenting evidence for the nearer approach of the female sex in man to the lower animals stated (Bibl. 34, S. 100 and 123) that they have more frequently a *trochanter tertius* and cited Houzé as his authority!

[1] The wording is obscure, but having regard to the preceding paragraph and the figures, we take Houzé to mean 62 °/₀ of third trochanter in all and 44 °/₀ of *fossa*.

Now remembering what we have noted of the continuous variation in intensity of both the *trochanter tertius* and the *fossa hypotrochanterica* we may treat these tables as representing continuous variates divided in tetrachoric form by the personal equation of Houzé. There result the correlations

$-\cdot 21 \pm \cdot 10$ for the polished stone age femora,

$-\cdot 02 \pm \cdot 17$ for the modern Belgian femora.

Or, we conclude that there is no marked association between these anomalies; indeed the presence of one seems to connote the absence of the other, rather than *vice versâ*. Summing up Houzé's statistical evidence we have the following results:

Races	Number	Third trochanter	Fossa hypotrochanterica
Quaternary Epoch	44	—	"very frequent"
Polished Stone Age	110	62 °/₀	44 °/₀
Merovingians	30	40 °/₀	23 °/₀
Inhabitants of Canaries.....	16(!)	56 °/₀	19 °/₀
Negroes	16(!)	18 °/₀	12 °/₀
Modern Belgians.....	67	34 °/₀	15 °/₀

Considering the smallness of the series[1] we are not able to accept as beyond question the view that primitive man more frequently exhibited these anomalies of the femur than modern man. Houzé divides the races of man into "megapygous" and "micropygous" (negroes), terming the anthropoids "platypygous"; but it is not clear that development of the buttocks—a well-developed "region fessière"—signifies that the great gluteal muscle (or "grand fessier") is also well developed. Houzé concludes that the third trochanter and the *fossa hypotrochanterica* result from the immense development of the *gluteus maximus* in man, the most voluminous of all the human muscles, and characteristic of his upright gait; the third trochanter and the edges of the *fossa* serve for the insertion of this muscle. This view of Houzé met with wide acceptance, and one frequently finds statements that these anomalies appear (*a*) in the primitive muscular races of man, and (*b*) in the muscular individuals of modern races. It is hard to understand how if they were due to the development of the *gluteus maximus* in man, they should remain anomalous in his case, and the rule in numerous lower types[2],

[1] There are grave doubts also as to what the numbers actually mean. For Merovingians and Canary Islanders Houzé gives no percentage figure for the combination, and we do not feel absolutely certain that his numbers for third trochanter and fossa are *exclusive* of combined appearance.

[2] The third trochanter is extremely well marked in the armadillo, but in the specimen we were able to dissect owing to the kindness of Professors Arthur Keith and Wood Jones, the *gluteus maximus*, although of extensive origin, was a rather thin sheet of muscle and not relative to other muscles of the same creature a very powerful muscle.

while their frequent appearance in infants, in women, and in bones of small muscular development at least precludes the theory that their appearance is *solely* due to use development. (See our Plates XXIX and XXXVI.)

In the same year (1883) as Houzé's memoir appeared a paper[1] by Dollo of Brussels was published which deals with the "third" trochanter in the *Dinosauria* (of which he takes as special illustration the Iguanodon) and in birds. This trochanter is on the upper part of the lower half of the diaphysis on the inner side and serves for the attachment of the caudo-femoral muscle. Dollo holds that it should be called the fourth and not the third trochanter, with which it has no relation. As far as we know no survival of this fourth trochanter has been recorded in the human femur unless the processes noted by Wilbrand[2] and Barkow[3] in the distal half of the femoral diaphysis are to be thus interpreted. (See our Plates XXIV, XXV, XXVII and XLI.)

Houzé's paper not only excited interest among the Belgians themselves, but through Albrecht led to a discussion on the subject at the Breslau Gathering of the German Anthropological Society, in which Von Török and Virchow took part. Von Török had denied the greater frequency of the third trochanter in women and Virchow[4] had drawn attention to the very different percentages obtained by different investigators. He himself had received a great mass of femora from a cave in the Canaries, not one of which had a *trochanter tertius*[5], while in a few ancient femora from Troas he found it in a hitherto unrecordedly high proportion (not stated). Instead of attributing a good deal of this divergence to the smallness of the samples and the great influence of personal equation, Virchow considered that there were probably great local differences, and attributed these to the customs and "Akkommodationsweisen" of individual peoples. Thus he seemed to assert the view—not unnatural to the pathologist—that use can produce very marked changes in a bone, *i.e.* he terms acquired characters in one species what are specific characters in a second.

Von Török published his observations at length in 1886[6]. He examined 54 skeletons, of which 38 were definitely known to be male and 16 female. Von Török classifies into "customary" ridge or *crista*, third trochanter and *fossa hypotrochanterica*. We think this is undesirable, as it does not distinguish between the ordinary gluteal ridge consisting of a succession of rugosities and the relatively smooth apophysis, which is an elongated *trochanter tertius*, and is indicated by the term *crista trochanterica*, or better *hypotrochanterica*. It has been noted by Dwight and

[1] Bibl. 30.

[2] J. F. Wilbrand: Ueber einen Processus supracondyloideus Humeri et Femoris. Giessen, 1843.

[3] H. C. L. Barkow: Anatomische Abhandlungen, S. 8—9. Breslau, 1851. Barkow describes Wilbrand's case and three similar ones as *Processus supracondyloideus externus*, they all were on the *linea aspera* 4 to 7 inches from under end of the external condyle and are said to correspond to third trochanter in the armadillo: see our discussion below, p. 83 *et seq.*

[4] Bibl. 33.

[5] Houzé had found for inhabitants of the Canaries 56 °/₀ and later Costa found the third trochanter on both of two Guanche femora, but we do not know whether Houzé's or Virchow's Canary femora were Guanche.

[6] Bibl. 41.

Costa and appears to us something quite distinct from the customary gluteal ridge. Von Török found:

	♂	♀
Customary Ridge	25	19
Third Trochanter	4	5
Fossa Hypotrochanterica ...	14	1
Trochanter + Fossa	14	1
Trochanter + Ridge	10	5
Ridge + Fossa	9	1
	76	32
Percentage of Third Trochanter	37 °/₀	34 °/₀
Percentage of Fossa	49 °/₀	9 °/₀

Thus these anomalies do not appear more frequently in the female sex. Von Török says nothing about the intensity of the characters, and we do not know at what degree of elongation he would consider the trochanter to pass into the "ridge," or whether he would classify the *crista hypotrochanterica* as a third trochanter.

Von Török does not state the period of his femora, but since they were sexed there is little doubt that they were *modern* bones. This is of some importance, for immediately after Waldeyer's paper, C. M. Fürst, the Swedish anthropologist, had examined[1] 40 skeletons in Stockholm and 43 in Upsala. Of these 31 femora belonged to the stone age and there were ten of these with third trochanter, or 32 °/₀. Of 39 femora from Middle Ages onwards 12 or 31 °/₀ showed the same feature. Thus Von Török's numbers confirm Fürst's—about one-third of the femora, whether modern or ancient, showed the third trochanter. Of 83 skeletons 27 or 33 °/₀ had the third trochanter on one or both members; of 238 femora it occurred in 69, or 29 °/₀. Allowing for personal equation the agreement of Fürst and Von Török is really very close, and more than sufficient to throw doubt on Houzé's view that the presence of the third trochanter is especially marked in primitive man. Further, Fürst found the process in two women on both sides, in a boy of 14 years, and in a male of 22 years on both sides at Stockholm, and of the three especially developed cases at Upsala, one was a boy of 13 years and the second a woman. Von Török had also found practically as large a percentage occurrence in women as in men. Thus it seems impossible to assert that muscular development itself can be the origin of the third trochanter, or that it can have anything to do with use, as Virchow appears to suggest.

Three other papers having some numerical data may be considered here. Pietro Costa published a lengthy paper in 1890[2]. While Houzé found the *fossa hypotrochanterica* in 15 °/₀ of modern Europeans and much more frequently in early man, Costa found it in nearly double this number, 29·4 °/₀, which is either

[1] Bibl. 28. Fürst only classifies by presence or absence, but as he states that the most marked *trochanter tertius* he observed was 12 mm. high, 40 long and 1·5 broad, it is clear that what we should call a crest, he includes in his third trochanter group.

[2] Bibl. 51.

a sign of a great difference of personal equation or else of extreme local variation[1]. Costa found in 37 Fuegian femora the *fossa* present in every case and in 94·6 °/₀ (35 instances) the third trochanter, which is evidence at least of the presence of these anomalies in a primitive race. In a group of 44 femora of primitive races[2] the third trochanter occurred in 47·7 °/₀, while among modern Europeans (102 femora) it only occurred in 30·4 °/₀. Costa's numbers are small—except in the case of Europeans—but as far as they go are in favour of Houzé's conclusion. Costa lays stress on considering the difference between what we classify as "nipple" and "crest" forms of the third trochanter[3] (both of which are distinct from the "ala" form as found in the rhinoceros, ass and armadillo, but no approach to the "ala" form has ever been noticed by us in human femora). He considers the three anomalies *trochanter tertius*, hypotrochanteric fossa and crista as *signi regressivi*[4], atavistic manifestations and independent of the development, greater or less, of the gluteal muscle, which uses them for its insertion[5]. Evidence in favour of this view is drawn from its nearly constant appearance with the Fuegians, who are not a muscular race. Costa draws attention to Houzé's classification of "megapygous" and "micropygous," but development of the rump may be due to other causes than muscle, and the *trochanter tertius* appears to be rare in the negro; but are all negroid races micropygous, as Houzé assumes? Costa notes that the third trochanter appears constantly in the *Lemuri*; in the specimen examined by him he found it in association with the hypotrochanteric *fossa* and a small crest. He further found a third trochanter in *Hylobatis agilis*, and in a chimpanzee. In an orang utan he observed the hypotrochanteric *fossa* and a crest, but in a gorilla he found only the *fossa*. If we disassociate the volume of the *gluteus maximus* from the problem of the origin of its insertion in the third trochanter, we free ourselves from many difficulties. Why, if the *gluteus maximus* is the chief characteristic muscle of man and associated with his vertical position, is the third trochanter only occasional in man, but universal in the rabbit? It is clearly very persistent in certain quadrupeds, but apparently is disappearing in the primates.

The view that it is very prevalent in primitive man does not seem really well established, but if established would only tell against direct descent from the anthropoid apes and not against a common ancestry. Costa has to

[1] We must note that Von Török had found the fossa in 40 out of 108 or 37 °/₀ of modern bones.

[2] Africans, Australians, Guanches, etc.

[3] The crest (crista or Leiste) is the customary form in the Carnivora, *e.g. Vulpes vulgaris.*

[4] Bibl. 51, p. 294.

[5] We would note, however, that it is not a valid argument to cite cases of the third trochanter appearing in the femora of infants and even of fetuses as proving that it is independent of muscular development, for it may be an antecedent sign of coming muscular development. Of course its appearance in infants and fetuses is an argument against its *production* by muscular development, which some anatomists assert. We ourselves have found a third trochanter well marked in very slightly built female femora and in some adult femora of very poor muscular development, or of feeble and diseased character: see our Plates XXIX and XXXVI.

admit that the European races of man, the apparently highest races, have a large percentage of both *trochanter tertius* and *fossa hypotrochanterica* apparently more than the negroes, but he accounts for this on the ground that the development of the European races has ceased to be physical and has become psychical, and cites Dollo, Wallace and Lubbock to this effect. This view seems scarcely reconcileable with his further statement that the lowest races of man, Fuegians and Guanches (as nearest to the Cro-magnon type), with the largest percentages of third trochanter and *fossa* are—like Europeans who exhibit them—reversions to lower animals which invariably have them. To support this argument Costa turns to criminals, who, he says, resemble in somatic and psychical characters an inferior race, and he cites[1] an investigation made on 136 femora of criminals in the Institute of Human Anatomy at Parma. He states that there is an exaggerated frequency but gives no percentages. We have examined his descriptions of the femora of these criminals and it would appear that 26 (or 28) out of 136 bones exhibited the third trochanter, that is 19·1 °/₀ (or perhaps 20·6 °/₀). Now Costa had already given for 102 modern Europeans 30 cases, or 30·4 °/₀; Houzé found 34 °/₀ among modern Belgians, Fürst about 33 °/₀, Von Török about 37 °/₀ and we ourselves in 810 English femora found 425 or 52·5 °/₀ with some appearance of a *trochanter tertius* or *crista hypotrochanterica*!

Such is the influence which Lombroso's theory—that criminals exhibit degenerative stigmata—can have in warping the judgment when no appeal has been made to actual numbers: "Questi i resultati che c' indicano come assuma il terzo trocantere nei criminali talora proporzioni esagerati: e questo fatto mi sembra sia sempre più in appoggio sul considerare il terzo trocantere e naturalmente con lui fossa e la cresta che spesso vi s' associano, come segni di regresso, di inferiorità, come segni di atavismo."

We agree entirely with Costa that the third trochanter in man is not the product of muscular development, although it serves as one of the methods of insertion of the *gluteus maximus*, and we also look upon it as evidence of evolutionary history, but we cannot accept the view that it is a sign of some vague "inferiority"—not adequately defined as either physical or psychical—and illustrated by its presence in the criminal population to an exaggerated degree.

Fifteen years later (1905) another Italian scientist returned to the subject of the third trochanter[2]. We have not been able to discover the original paper of Zuccarelli, if indeed it was ever published, but we have seen abstracts of it. He divides the third trochanter into *fourteen* types by somewhat fanciful analogies to mountains, mountain ranges, half-chestnuts, kidney-beans, caterpillars, etc. He examined 123 femora and found the *trochanter tertius* in 23·6 °/₀. He says that in the mountain, chestnut and caterpillar forms it varies in length from 20·3 to 35·2 mm., in breadth from 8·3 to 19·0 mm. and in height from 4·0 to 12·0 mm. But this leads us to the important point we have to make, namely, that the

[1] Bibl. 51, pp. 298—9.

[2] Bibl. 94.

minimum limits are perfectly arbitrary and solely the result of personal equation. If 800 or 900 femora are examined together a perfect series of diminishing *trochanter tertius* will be found, and although it is possible to say of some bones they have, and of others they have not, a third trochanter, it is almost impossible to say here the third trochanter ends and there it begins. It is purely a matter of personal equation, and for this very reason we doubt the possibility of comparing percentages given by different observers. Here there is a third trochanter and there there is no third trochanter, an observer will say of two femora; but now fill up the gap between the two bones continuously with a graduated series of 50 or 60 bones, and then the limit to the *trochanter tertius* series will either be admitted to have vanished, or be assumed in a perfectly arbitrary manner, which is incapable of any definition, beyond vague impression or opinion. We should have no objection to Zuccarelli's minimum dimensions, if they had been taken by everybody as standard values. But that third trochanters 15 mm. long, 7 mm. broad and 3 mm. high exist, we confidently assert; and we see no reason but arbitrary convenience for stopping at these or any other limits when there is a process in the proper position clearly differentiated from the mere termination of the gluteal ridge.

Zuccarelli, after making statements in agreement with Houzé and Costa about the greater prevalency of the third trochanter in ancient femora[1], then asserts that the presence of the third trochanter has no relation to the greater development and robustness of the individual femur ("La presenza del tr.[3] non è nient' affato in rapporto con un più vantaggioso grado di sviluppo e robustezza femorale"), an opinion with which we should agree.

Some of his other conclusions—probably drawn from very inadequate numbers—are exceedingly doubtful, *e.g.*:

(*a*) The third trochanter is most frequently and ordinarily unilateral.

(*b*) It is more prevalent in the right femur.

(*c*) Its prevalency is well marked among those who may from well-founded records be supposed to be degenerates.

(*d*) There is a high percentage among rogues.

(*e*) The third trochanter in its three most characteristic types ("monte, mezza-castagna, bruco") is associated with the pilastric femur.

We shall consider these statements from the data provided by other observers as well as our own.

In 810 London femora where we could consider the *trochanter tertius* and the *fossa hypotrochanterica* we have:

[1] He says that in ancient femora before and since the Christian epoch it varies from 11·1 °/₀ to 26·3 °/₀ while in modern femora it is about 5·6 °/₀. As the chief modern series show at least 20 °/₀ to 30 °/₀ in the case of other observers, these mere percentages of Zuccarelli fail to convince.

Anomaly →	Trochanter Tertius						Fossa Hypotrochanterica					
	♂			♀			♂			♀		
Side →	R.	L.	R.+L.	R.	L.	R.+L.	R.	L.	R.+L.	R.	L.	R.+L.
Total Femora	225	236	461	170	179	349	225	236	461	170	179	349
Femora with anomaly	103	122	225	87	113	200	84	100	184	38	53	91
Percentage	45·8	51·6	48·8	51·2	63·1	57·3	37·3	42·4	39·9	22·4	29·6	26·2

Thus we found that in the case of both male and female for both *trochanter tertius* and *fossa hypotrochanterica*, the left bone presents the anomaly more frequently than the right. This is directly opposed to Zuccarelli's conclusion (*b*) above. Further we find the *trochanter tertius* somewhat more prevalent in female (the less muscular) than in the male (the more muscular) femora[1], while the *fossa hypotrochanterica* is markedly less prevalent in the female than in the male bones[2].

It will be seen that our values approach in magnitude those which Houzé has given for early and primitive races. While we lay no stress on this, as there is no measure of our relative personal equations, we still believe it discounts much of the emphasis which has been laid on the greater prevalence of the third trochanter in early and primitive races.

Evangeli-Tramond[3] examined 60 ♂ and 60 ♀ femora and obtained the results:

Anomaly →	Trochanter Tertius		Fossa Hypotrochanterica	
	♂	♀	♂	♀
Total Femora	60	60	60	60
Femora with anomaly...	9	15	29	22
Percentage	15·0 °/₀	25·0 °/₀	48·3 °/₀	36·7 °/₀

[1] This appears to be in accordance with Ludewig's result, who seems to have found the third trochanter in 36 out of 100 femora, and 28 of these were female. Unfortunately he does not say how many of the 100 were female! See Bibl. 56, p. 16.

[2] If the third trochanter and *fossa* are signs of inferiority or of "animalism" according to Albrecht, then to determine whether man or woman is more "animal," we should have to ask whether the trochanter or the *fossa* is to be considered lower in origin.

[3] Bibl. 65.

These percentages differ widely from ours, but they confirm the view that the third trochanter is more prevalent in female, the *fossa* in male bones[1].

From the time of Houzé onwards many anthropologists and anatomists have supposed a marked association to exist between the presence of the third trochanter and that of the *fossa hypotrochanterica*. We have aleady noted that this association is not manifest in Houzé's own material (see our p. 68). For our English data we determine the fourfold table:

Fossa Hypotrochanterica	Third Trochanter: Present	Third Trochanter: Absent	Totals
Present	155	120	275
Absent	270	265	535
Totals	425	385	810

Using the tetrachoric process to determine the correlation we have

$$r = +\cdot 09 \pm \cdot 04;$$

it is clear therefore that in English femora as in those of the polished stone age, and in modern Belgian femora, there is no significant association between the presence of these anomalies. We further considered this point in fairly long series of Naqada Egyptian femora. The data give

Hypotrochanteric Fossa	Male (R.+L.) Third Trochanter			Female (R.+L.) Third Trochanter		
	Present	Absent	Totals	Present	Absent	Totals
Present.....	37	75	112	40	61	101
Absent.....	120	156	276	140	181	321
Totals	157	231	388	180	242	422
Correlation	$r = -\ 16 \pm \cdot 06$			$r = -\cdot 06 \pm \cdot 06$		

Both of these are negative, but neither is very definitely significant and both confirm the result obtained from the English femora, that there is no marked relation between the presence of the hypotrochanteric *fossa* and that of the third trochanter.

[1] Costa merely gives 38 sexed skeletons, of which only 8 were female, thus the percentages obtained from his data, when divided up into R. and L., ♀ and ♂ categories, show no significant differences. Bibl. 51.

We consider that the large number of bones here dealt with is sufficient to settle finally the point, but it is only fair to the reader to indicate that much smaller series for special races do not always agree with the results of Houzé's data and our two lengthy series.

Thus we are able to present the following tables:

Third Trochanter

Fossa Hypotrochanterica	Guanches (Bertaux)[1]			Negroes (Bertaux)[1]			Modern Italians (Costa)[2]			Modern French (Evangeli-Tramond)[3]		
	Present	Absent	Totals	Present	Absent	Totals	Present	Absent	Totals	Present	Absent	Totals
Present ...	15	1	16	1	2	3	27	19	46	11	41	52
Absent ...	20	12	32	4	27	31	7	23	30	13	55	68
Totals ...	35	13	48	5	29	34	34	42	76	24	96	120
Correlation	$+ \cdot 62 \pm \cdot 12$			$+ \cdot 35 \pm \cdot 29$			$+ \cdot 54 \pm \cdot 10$			$+ \cdot 10 \pm \cdot 11$		

It will be observed that these four series are very short, but still two of them show no association having regard to their probable errors. But in the case of the Guanches and modern Italians, notwithstanding the shortness of the series, the association is sensible. We cannot account for this except on the ground we have already referred to, *i.e.* the great difficulty in settling where a third trochanter starts and when a slight depression is to be considered a *fossa*. Once this is realised it is not difficult for an observer who notices one anomaly to look in that case more closely for the signs of a second, especially if he is aware that association between the two has already been asserted to exist. It is, perhaps, only possible for the statistician inherently doubtful of every statement not based on figures to give an independent judgment[4].

We can, on our data, give no evidence for or against Zuccarelli's statement that the degenerate and the criminal (conclusions (*c*) and (*d*)) exhibit a marked prevalence of the third trochanter; we have, however, already shown in the case of Costa's data for criminals that the statement is incorrect, at least for his records: see our p. 72.

Very brief examination of already published material suffices to refute Zuccarelli's statement (*a*), that the third trochanter is most frequently and ordinarily unilateral.

[1] Bibl. 32, pp. 199—204, 207—8. [2] Bibl. 51. [3] Bibl. 65, p. 90 *et seq.*

[4] Having read the anatomical opinion on the subject I found myself most carefully searching for a *fossa*, wherever I noted a third trochanter. Only after my colleague had recorded the presence or absence of these anomalies did I inform her that according to current opinion a high association was to be anticipated. But it failed to appear in our table! K. P.

We have the following tables:

Trochanter Tertius in Paired Bones.

First Femur

Paired Femur	Costa's Data[1]			Dwight's Data[2]			Fürst's Data[3]		
	Present	Absent	Totals	Present	Absent	Totals	Present	Absent	Totals
Present ...	26	9	35	62	7	69	36	9	45
Absent ...	9	32	41	7	96	103	9	112	121
Totals ...	35	41	76	69	103	172	45	121	166
Correlation	+ ·73 ± ·07			+ ·96 ± ·01			+ ·92 ± ·03		

It will be seen that there is very high association indeed between the presence of a third trochanter (or its absence) on both of any pair of femora, and Zuccarelli's statement is inexplicable.

Similar conditions prevail with regard to the *fossa hypotrochanterica* and Poirier's facet of the neck[4], as the following tables indicate:

Fossa Hypotrochanterica and Poirier's Facet in Paired Bones.

Paired Femur	Costa's Data[1] Fossa Hypotrochanterica			Poirier's Facet, Bertaux's Data, First Femur[5]		
	Present	Absent	Totals	Present	Absent	Totals
Present.....	40	6	46	12	1	13
Absent.....	6	24	30	1	8	9
Totals	46	30	76	13	9	22
Correlation	+ ·87 ± ·05			+ ·95 ± ·04		

As our London material consisted entirely of unpaired bones the Naqada Egyptian material at Cambridge, which is given by skeletons, was examined by the

[1] Bibl. 51, p. 284.

[2] Bibl. 50, p. 62. This table is the best we can make of Dwight's data which are not clearly recorded.

[3] Bibl. 28, S. 321.

[4] An anomaly to be discussed below.

[5] Bibl. 51, p. 312 *et seq*

kind permission of Prof. Alexander Macalister. We were able to deal with paired abnormalities in 250 to 300 paired bones. The results are given here although some of the abnormalities will only be discussed later in this chapter.

Bilateral or Unilateral Abnormalities in Naqada Bones.

Left Femur	Third Trochanter Right Femur		
	Present	Absent	Totals
Present ...	89	38	127
Absent ...	36	122	158
Totals ...	125	160	285
Correlation	$r = +\cdot680 \pm \cdot041$		

Left Femur	Hypotrochanteric Fossa Right Femur		
	Present	Absent	Totals
Present ...	49	47	96
Absent ...	17	191	208
Totals ...	66	238	304
Correlation	$r = +\cdot729 \pm \cdot042$		

Left Femur	Crural Fossa Right Femur		
	Present	Absent	Totals
Present ...	32	15	47
Absent ...	28	223	251
Totals ...	60	238	298
Correlation	$r = +\cdot778 \pm \cdot044$		

Left Femur	Poirier's Facet Right Femur		
	Present	Absent	Totals
Present	183	25	208
Absent	26	31	57
Totals	209	56	265
Correlation	$r = +\cdot663 \pm \cdot055$		

Left Femur	Tubercle, Internal Head of Gastrocnemius Right Femur		
	Present	Absent	Totals
Present	157	20	177
Absent	32	45	77
Totals	189	65	254
Correlation	$r = +\cdot728 \pm \cdot044$		

The above results are for paired bones without regard to sex. Notwithstanding that the pairing is not wholly beyond question[1] the correlations are markedly high, and we conclude that so far from anomalies being unilateral they occur most generally in both of a pair.

We do not hesitate to assert that all the anomalies which we personally have dealt with occur in the majority of instances bilaterally.

Lastly we turn to Zuccarelli's statement that the third trochanter is associated

[1] The bones were not seen in pairs, but both femora of a pair carry the same number, which is the *grave* number; now in rare cases experience has shown that through accident or double interment the femora do not pair; further since 1896 certain of the femora appear to have been renumbered and may bear *two* numbers; thus the above values are really minimum values of the correlation coefficients.

with a pilastric femur. This *à priori* seems improbable if, as we hold, the third trochanter is a reversion and the pilastric femur is something peculiar to man.

The following table gives the distribution of the pilastric index for combined male and female femora with and without the third trochanter:

Pilastric Index (♂, ♀, *R. and L.*).

Trochanter Tertius	65–68	69–72	73–76	77–80	81–84	85–88	89–92	93–96	97–100	101–104	105–108	109–112	113–116	117–120	121–124	125–128	129–132	133–136	137–140	141–144	145–148	Totals
Present ...	1	—	3	2	9·5	18·5	34	50	60	72	57	56·5	26·5	14·5	6	4·5	1	—	—	—	1	417
Absent ...	1	—	—	2	4	8	19	36	57	60	60·5	45	45·5	21	6	4	1	1	—	—	—	371
Total Population	2	0	3	4	13·5	26·5	53	86	117	132	117·5	101·5	72	35·5	12	8·5	2	1	—	—	1	788

The mean pilastric index for the whole population = 103·20, for the bones with third trochanter = 102·09, and for those without 104·45. Thus those with a third trochanter are the *less* pilastric bones. The biserial correlation between emphasised third trochanter and emphasised pilastric index is $-\cdot151 \pm \cdot030$. There is thus, as seemed probable *à priori*, a small but sensible correlation between pilastry and the *absence* of the third trochanter.

A somewhat similar statement connecting the hypotrochanteric *fossa* with platymery has been made; it is not, however, accepted by Evangeli-Tramond[1]. The table below gives the platymeric indices for combined male and female femora with

Platymeric Index.

Fossa Hypotrochanterica	64–66	67–69	70–72	73–75	76–78	79–81	82–84	85–87	88–90	91–93	94–96	97–99	100–102	103–105	106–108	109–111	112–114	115–117	Totals
Present	—	6	10·5	32·5	30·5	43	47·5	39	27	23	8	7	5	2	2	1	—	—	284
Absent	4	15	30	40	73·5	62·5	82·5	68	47·5	49·5	28·5	19	20	7	8	4	2	5	566
Totals	4	21	40·5	72·5	104	105·5	130	107	74·5	72·5	36·5	26	25	9	10	5	2	5	850

and without the *fossa*. Here the mean platymeric index for the whole population = 84·20 and for the bones with a hypotrochanteric *fossa* = 83·26, while for the femora without it is 84·67. The biserial correlation between presence of a *fossa* and emphasised platymery (low index) is $+\cdot096 \pm \cdot030$. Thus there is a small but just sensible correlation between platymery and the presence of the *fossa hypotrochanterica*. This is in accordance with what we might *à priori* have anticipated, when we remember the occasional association of lateral protrusion and the *fossa*; see Plates XXXVI and XXXIX. These investigations may suffice to

[1] Bibl. 65, p. 57.

warn the reader against very general statements made on very inadequate data. We find it difficult to accept any one of Zuccarelli's conclusions as applying to our material.

(iii) *The Crural Trough*[1]. This is a depression which starts either at the base of the great trochanter or on the neck close to the great trochanter and runs vertically down the anterior face of the shaft. When slight it can often be easily felt with the finger, while hardly sensible to the eye. Our Plate XXXVII shows various grades of it in English femora. In the first the crural trough is broad and deep, but does not extend far down the shaft; in the second the trough is deep and long, extending quite to the middle of the shaft; in the third it is broad and not very deep; while in the fourth it has little more than the appearance of a "thumb-mark" at the base of the great trochanter.

The crural trough, while occurring only occasionally in the human femur, is almost characteristic although not always very deep in the Primates. It occurs in the gorilla, although usually more marked in male than female. In the chimpanzee it is usually less marked than in the gorilla, and the orang-outang has it in about the same degree as the chimpanzee. In the gibbon there is only a slight crural depression. These observations are based on specimens in the Musuem of the Royal College of Surgeons. Bello y Rodriguez[2] notes that chimpanzee, gorilla and orang often have this crural depression. It seems, to judge from the drawings of the Trinil femur (Dubois, Bibl. 67, Plate II. fig. 1), well marked, broad and deep but not running very far down the shaft in *Pithecanthropus erectus*. In Neolithic femora Rodriguez found it ten times in 154 ♂ bones and only once in 89 ♀ bones. He found it twice in 92 Japanese femora, once in 94 Berbers and Guanches. In Peruvian femora (of which he shows a good photographic illustration of a well-marked crural trough: see also our Plate XLI, fig. (II) for a Patagonian) it occurred twice well marked, twice moderately marked and eleven times feebly in 72 femora. But in 72 French femora, 48 Negro femora and 54 Polynesian femora, it did not occur once. In the ancient Gauls it occurred seven times in 50 femora. Thus it would appear to be more frequent in primitive and ancient races than among modern Europeans. As in the case of the *fossa hypotrochanterica*, we find it difficult to assert where the crural trough begins. Subject to this we found it in 271 out of 881 English bones or 29·6 %.

In the following table (I) denotes a well-marked case, (II) distinctly present in definite form, (III) some trace, slight trough or *fossa*, as the case may be.

It will be seen that in its well-marked form the crural trough is slightly rarer than the *fossa hypotrochanterica*, but if we consider (I) and (II) the percentages are 14·2 % as against 12·6 %, which are again reversed, if we take all traces (I)—(III), the crural trough then appearing in 29·6 % of femora and the *fossa hypotrochanterica* in 33·5 %. Actually these percentages should be read as:

Crural Trough	29·6 % ± 1·0 %;
Hypotrochanteric *Fossa*	33·5 % ± 1·1 %.

[1] "Gouttière crurale" of the French writers.

[2] Bibl. 101.

Crural Trough

Fossa Hypotrochanterica	(I)	(II)	(III)	Absent	Totals	°/₀
(I)	1	1	3	11	16	1·8
(II)	0	8	13	74	95	10·8
(III)	2	29	26	127	184	20·9
Absent	7	77	94	408	586	66·5
Totals	10	115	136	620	881	—
°/₀	1·1	13·1	15·4	70·4	—	—

It is not therefore demonstrated that the crural trough is actually rarer than the hypotrochanteric *fossa*. At the same time it probably does not catch the eye to the same extent.

We inquired whether the presence of these two anomalies was in any way associated. The fourfold table gives:

Crural Trough

Hypotrochanteric Fossa	Present	Absent	Totals
Present ...	83	212	295
Absent ...	178	408	586
Totals ...	261	620	881

leading to $r_t = -\cdot016 \pm \cdot039$.

In 1198 Egyptian bones we found the following occurrences:

Crural Trough in Naqada Femora.

		(I)	(II)	(III)	A	Total	(I)—(III)
Definite ♂	Absolute	2	15	51	319	387	—
	Percentage	0·51 °/₀	3·88 °/₀	13·18 °/₀	82·43 °/₀	—	17·57 °/₀
Definite ♀	Absolute	7	15	59	335	416	—
	Percentage	1·68 °/₀	3·61 °/₀	14·18 °/₀	80·53 °/₀	—	19·47 °/₀
Doubtful Sex	Absolute	4	5	59	327	395	—
	Percentage	1·01 °/₀	1·27 °/₀	14·94 °/₀	82·78 °/₀	—	17·22 °/₀
Total	Absolute	13	35	160	981	1198	—
	Percentage	1·09 °/₀	2·92 °/₀	14·10 °/₀	81·89 °/₀	—	18·11 °/₀

The probable error of the (I)—(III) percentages is about 1·3, so that the apparent sexual difference of ♂ and ♀, 17·57 °/₀ and 19·47 °/₀ respectively, is not significant if measured from the percentage 18·11 °/₀ of the whole population[1]. Thus in these bones, supposed to date from over 5000 B.C., well-marked cases of the crural trough only occur in about 4·0 °/₀ of instances, and the total of cases is only 18·1 °/₀ as against 29·6 °/₀ in our English femora. Accordingly we cannot confirm the view that it is less frequent in modern bones—it appears on the contrary to be a racial character[2].

We tested the sex-difference again on our English femora, including such non-adult bones as had been sexed and omitting some bones of indeterminate sex. The conclusions are given in the tables below. It will be seen that there is the same absence of association between crural trough and hypotrochanteric *fossa* when separate tables for the sexes are drawn up, but that the crural trough is now found to be sensibly more frequent in the female (35·97 °/₀) than the male femora (24·95 °/₀).

Hypotrochanteric Fossa	English Males (R. + L.) Crural Trough			English Females (R. + L.) Crural Trough		
	Present	Absent	Totals	Present	Absent	Totals
Present ...	48	152	200	31	66	97
Absent ...	78	227	305	110	185	295
Totals ...	126	379	505	141	251	392

Correlation : $r = -\cdot031 \pm \cdot052$ and $r = -\cdot085 \pm \cdot059$.

This might suggest that relatively the *gluteus maximus* was more developed in man than woman and the *vastus intermedius* in woman than man. But the absence of any similar relation in the Naqada Egyptian bones is against laying much stress on this as a general conclusion. We have indicated this in the case of the crural trough; the data for the hypotrochanteric *fossa* are as follows:

Hypotrochanteric Fossa in Naqada Femora.

		(I)	(II)	(III)	A	Total	(I)—(III)
Definite ♂	Absolute	13	36	63	276	388	—
	Percentage	3·35 °/₀	9·28 °/₀	16·24 °/₀	71·13 °/₀	—	28·87 °/₀
Definite ♀	Absolute	11	24	66	321	422	—
	Percentage	2·61 °/₀	5·69 °/₀	15·64 °/₀	76·07 °/₀	—	23·93 °/₀
Doubtful Sex	Absolute	18	32	67	268	385	—
	Percentage	4·68 °/₀	8·31 °/₀	17·40 °/₀	69·61 °/₀	—	30·39 °/₀
Total	Absolute	42	92	196	865	1195	—
	Percentage	3·51 °/₀	7·70 °/₀	16·40 °/₀	72·88 °/₀	—	27·62 °/₀

[1] The sex difference for the most marked cases (I) and (II) is also not significant.

[2] We should hesitate, however, to compare our percentages with Rodriguez's because so much depends on personal equation.

It is clear that the best chance of obtaining a significant sex difference is to consider only the more marked cases of the fossa, *i.e.* (I) and (II). These give:

$$\text{♂}, \quad 12{\cdot}63\ ^{\circ}/_{\circ} \pm 1{\cdot}14\ ^{\circ}/_{\circ},$$
$$\text{♀}, \quad 8{\cdot}30\ ^{\circ}/_{\circ} \pm 0{\cdot}90\ ^{\circ}/_{\circ},$$

leading up to a difference of

$$4{\cdot}33\ ^{\circ}/_{\circ} \pm 1{\cdot}46\ ^{\circ}/_{\circ}$$

or, say, 2·9 times its probable error. That is to say, we are just verging on real significance, but cannot do more than assert that the *fossa* is probably more marked in the Naqada male than the Naqada female.

We have further tested in the Naqada material the possibility of the crural trough being associated in the evolutionary development of the femur with the presence of the third trochanter. We have the following tables:

Crural Trough	Male (R.+L.) Third Trochanter			Female (R.+L.) Third Trochanter		
	Present	Absent	Totals	Present	Absent	Totals
Present	28	40	68	45	36	81
Absent	129	190	319	132	203	335
Totals.....	157	230	387	177	239	416
Correlation...	$r = +\cdot011 \pm \cdot064$			$r = +\cdot230 \pm \cdot058$		

The result is here somewhat inconclusive; there is no significant relation in the male, but there appears to exist a small but definite relation in the female. It is so small, however, that but little argument can be based upon it; we cannot say that in the female femur when the trough is present we shall as a rule find the third trochanter.

There is thus certainly no marked association.

We look upon the crural trough as being like the third trochanter and the hypotrochanteric *fossa* a reversion to earlier forms, but it seems clear that such forms are not a single ancestral form that combined the third trochanter, the *fossa* and the trough. The apes show as a rule the crural trough but not the third trochanter.

(iv) *Wilbrand's Process* (called by Barkow: *Processus supracondyloideus externus femoris*). A *processus supracondyloideus internus* was first noticed on the humerus. Here the process is always on the internal side in a definite position giving an arch through which the median nerve and sometimes the superior profunda artery pass. Wilbrand in 1843[1] was, we believe, the first to

[1] See reference p. 69, ftn.

record a process on the femur, which occurred in his case on the lower third of the bone at the origin of the short head of the *biceps femoris*. He compared this process with the process on the external side of the femur in the armadillo, beaver and tapir—*i.e.* the process usually spoken of as the third trochanter. Barkow[1] in 1851 described three preparations in the Breslau Anatomical Museum which exhibited similar processes to that described by Wilbrand. He also compared them to the third trochanter in various animals, remarking that this trochanter in horse and tapir is above the middle of the shaft, in the beaver about the middle, but below in the case of the armadillo[2]. In all cases it springs from the ridge which corresponds to the external lip of the *linea aspera* in man[3]. Its position seems to be very variable, it may be below the popliteal apex on the external supracondylar ridge, or in other cases at the middle of the shaft before the *labia* have separated, or as much as seven inches above the level of the external condyle. In examining nearly 2000 femora, English and Egyptian, we have only found one English and four Egyptian cases which provide processes which by their position and *dimensions* correspond at all with that described by Barkow. The English bone itself, L. S. 216, exhibits a small *fossa hypotrochanterica* surmounted by a trace of a third trochanter. The process itself is figured in Plates XXIV and XXVII, and is situated slightly above the middle of the shaft; it would be difficult to state whether it lies on the external or internal lip, for it is astride of the *linea aspera*, being slightly more mesial than lateral because the *linea aspera* is here so. Its width is 1·3 mm., it involves a length of about 40 mm., and its height above the internal lip is about 7 or 8 mm. The *linea aspera* runs up into the process and the pilaster appears to cease entirely where the process ends.

It appears difficult to associate such a process with the *third* trochanter, for the same bone has traces of a third trochanter in the usual situation, unless we assert that, as we know the third trochanter can take a great variety of positions in different animals, so in man as an atavism it can take any position on the gluteal ridge, *linea aspera* and external condylar ridge, and even appear in two

[1] See reference p. 69, ftn.

[2] In a preparation of *Dasypus sexcinctus* which we owe to the great kindness of Profesor Keith the third trochanter stretched over the whole middle third of the bone, but its position was rather to the upper than the lower half of the shaft. G. Cuvier in his *Anatomie comparée*, recueil de planches de myologie...Paris, 1849, gives a plate (Vol. II, Pls. 259, 260 "Tatau à six bandes") of *Dasypus sexcinctus* and shows a muscle (unnamed) in part apparently differentiated from the *gluteus maximus* proceeding from the region of the tail to about the middle of the femur. We had some hope that this would turn out to be a caudo-femoral muscle comparable with that muscle in birds, and leading rather to a "fourth" than a third trochanter. Dr Wood Jones most kindly undertook an examination for this muscle in the above mentioned specimen from Professor Keith, but no differentiated portion of the *gluteus maximus* with differentiated insertions was discoverable.

[3] The difference between external and internal condylar ridge in the case of the femur and humerus would be less significant, if we accepted Martins' theory of the humerus being comparable with the femur torted through 180°, but there is no significant region in this locality in the case of the femur as in that of the humerus, *i.e.* we are not dealing with any definite muscular insertion or nerve origin.

places on one human femur. It may be noted that the site of the process is almost exactly the centre of ossification of the shaft, and it might therefore be an exostosis due to exuberant ossification. But as the *trochanter major* and *trochanter minor* have their separate centres of ossification, and such a centre has been asserted to exist for the third trochanter in man[1], the association with a centre of ossification might not be unreasonable in the case of an atavism. Imagination might run riot if we ventured to refer to the fourth trochanter of Dollo in the Iguanodon and in birds, especially as that appears in his cases to be definitely on the mesial side, associated with a caudo-femoral muscle, and in the distal half of the bone. In specimens, however, of wild duck and wild goose (see Plate XLI, fig. (i) *a* and *b*) we have found it almost to coincide with the popliteal apex. We have met occasionally with slight elevations of the external lip or the upper part of the *linea aspera*, but this is the only English case which appears to be in the least comparable with the processes described by Wilbrand[2] and in particular by Barkow[2]. We do not think that the term *processus femoris supracondyloideus externus* at all aptly describes the process and we prefer to call it *Wilbrand's Process.* Gruber[3] ridicules the existence of this process, but does so chiefly on account of its inaptly chosen name and its association with the third trochanter. He had himself found an apophysis *tuber supracondyloideum ossis femoris internum* or *processus supracondyloideus ossis femoris internus* in 123 out of 260 subjects. It is quite close to the internal condyle, between the internal lip of *linea aspera* and the middle line of popliteal surface, perhaps $\frac{1}{2}''$ above the internal condyle. Gruber considers it a muscular process produced by pull of the *M. gastrocnemius internus*[4]. See our Plates, XXII and XXIII; we have recorded it as tubercle of internal head of *gastrocnemius.* Gruber then says that a *processus supracondyloideus ossis femoris externus* should be a developed apophysis of the small tuberosity, which Gruber calls *tuber supracondyloideum externum.* This latter lies $\frac{1}{4}''$ to $\frac{1}{2}''$ above the inner side of the external condyle. It serves for the insertion of *M. plantaris.* Gruber himself had never found such a process, although the tubercle was not very uncommon[5]. As for Wilbrand's process Gruber considers that if it has any existence at all it is only a chance exostosis. The whole of Gruber's criticism with regard to the terminology may be, and in fact must be, admitted. But the reader has only to examine our Plates XXIV and XXV; he must admit that Wilbrand and Barkow were drawing attention to an apophysis which has striking resemblance in general position and appearance to the apophysis in the middle of the shaft of *Dasyprocta* and the goose. It may be that in the five bones in which we have come across it, it is in every case an accidental exostosis. But on the whole it is singularly constant in position, and we have not found these processes at other points of the *linea aspera.*

If Wilbrand's process be finally settled to be a mere accidental exostosis,

[1] Geddes, Bibl. 105.

[2] For references, see our p. 69, ftn.

[3] Bibl. 3 *bis*, p. 99.

[4] "Durch Zug des *musculus gastrocnemius internus* hervorgebracht," *loc. cit.* S. 103.

[5] *Loc. cit.* S. 106—7.

then it is so rare that it deserves record, and some explanation of its appearance in the neighbourhood of the popliteal apex ought to be forthcoming. On the other hand its relation to the so-called third trochanter in *Dasyprocta* is not so wild and far-fetched as Gruber would cause us to believe, and his criticism is somewhat weakened by his vigorous attack on a terminology which was no doubt unsuitable, but at the same time conflicted with his own use.

(v) *Tuber supracondyloideum externum*, and *Tuber supracondyloideum internum*[1]. The most recent consideration of the supracondyloidal area that we have come across is due to Hentzelt[2]. He accepts Gruber's *tuber supracondyloideum externum* (*laterale*), associating it with the external head of *M. gastrocnemius* as well as *M. plantaris*. On the medial side he finds matters more complicated and he distinguishes between Gruber's *tuber supracondyloideum internum* (mediale) and a process which he terms the *processus muscularis labii medialis* and considers as something new (1911) and apparently overlooked. He finds this process in 250 out of 265 femora examined by him, or in 94·3 °/₀ of cases. This process according to Hentzelt occurs where the medial lip of the *linea aspera* (internal supracondylar ridge) passes on to the epicondyle. He says it is usually looked upon as a rugosity of the epicondyle at the end of the *labium mediale* and is not especially noted. On the *tuber supracondyloideum internum* arises, he tells us, the external portion of the internal head of gastrocnemius while "die mediale Portion zum Ansatz des *M. adductor magnus* tritt, der mit seinem langen Sehnenstrang am *Processus muscularis labii medialis* inseriert[3]." According to Hentzelt the united insertion of the internal portion of the internal head of *gastrocnemius* with the end-tendon of the *adductor magnus* had misled Gruber to identify his process with the *tuber supracondyloideum mediale*. If we might venture to express an opinion on the matter, it does seem to us that the tubercle given as *a* on Gruber's Tafel I, figs. 1—3, is not identical with the process shown as *a* on his Tafeln II and III. The latter is on the internal lip of the *linea aspera* almost at the point where it reaches the epicondyle; the former is on the popliteal plane and different portions of the internal gastrocnemius muscle proceed to the two. The two cases are shown in our Plates XXII, XXIII and XXVI. As we take it Hentzelt proposes to call the tubercle on the internal lip of the *linea aspera* his *processus muscularis labii medialis*, and he asserts that the end-tendon of *M. adductor magnus* is inserted there. But Gruber's Tafel II seems to indicate that the *portio inferior m. adductoris magni* passes it by with a *bursa synovialis accidentalis* intervening

[1] These tubercles were, as Professor Thane points out to us, first referred to by Alexander Munro (Primus). In his *The Anatomy of Humane Bones*, Edinburgh, 1726, he writes in dealing with the supracondylar region (p. 309): "and near the extremity of each of these ridges a small smooth Protuberance may be remarked where the two Heads of the *musculi gastrocnemii externi* take their rise." It is only needful to remark that Munro uses "externus" in the sense of superficial and he distinguishes *M. gastrocnemius externus* or *gemellus* from *M. gastrocnemius internus* or *soleus* in his terminology.

[2] Bibl. 106, S. 30 *et seq.* He describes three "Höcker" which he terms "Muskelhöcker" and like Gruber asserts "durch Zug verscheidener Muskeln entstanden sind" (S. 36). Such language appears to suggest that the muscle somehow existed before its area of insertion was developed.

[3] *Loc. cit.* S. 36.

and proceeds to the region of the adductor tubercle. We have only found the same sort of *processus* as that figured by Gruber in Tafeln I and II in one out of some 2000 femora examined, while Hentzelt states that he has found it in over 94 °/₀ of femora. Hentzelt's references to the "Endsehne" of *M. adductor magnus*, and to the point at which the *labium mediale* terminates, together with his percentage of occurrence, might have led us to consider his *processus muscularis labii medialis*[1] as coinciding with the adductor tubercle, had not that tubercle been well recognised in anatomy in 1911. Not being able to identify Hentzelt's process we have omitted it from our statistics. On the other hand, our *tuber supracondyloideum internum* corresponds to the area of insertion of the external portion of the internal gastrocnemius muscle and is always on the popliteal area. Gruber's process on the medial lip of the *linea aspera* seems to us differentiated from it, and in any marked degree we have only come across it in the case figured on Plate XXVI[2]. We term it *Gruber's Process* simply to distinguish it from the supracondylar tubercles.

In the table on p. 88 we have endeavoured to give a comparative display of what data are available for these supracondylar tubercles. Hentzelt's three classes are: (I) = "sehr stark entwickelt," (II) = "gut entwickelt," (III) = "angedeutet (als Tuberositas entwickelt)." They should correspond fairly closely with the classes we adopted for dealing with the Egyptian Naqada data, *i.e.* (I) = "well-marked case," (II) = "distinctly present in definite form," and (III) = "some trace if only slight." On the other hand, the classes we formed earlier for English bones, namely, (i) = "well marked," (ii) = sensible, (iii) = distinctly absent, or very doubtful if existent, if easier for classification are not very good for comparative purposes.

This table seems to show that *well-marked* cases of the *tuber supracondyloideum internum* or *externum* are rare, extremely rare in the latter case; they are, however, somewhat more common in man than woman. While Gruber and Hentzelt agree fairly well for the sum of (I) and (II) and do not differ widely from our Egyptian data, especially for males, no comparison can be made between our English (i) and (ii) and the Naqada (I), (II) or (III). All we can say is that well-marked cases have much the same frequency in all the races so far dealt with, and that it is very largely a matter of personal equation to determine total absence; the tubercle diminishes through every grade of rugosity to zero, even as the third trochanter does. We doubt whether a satisfactory study of the presence or absence of these tubercles is possible and should be inclined in any future investigation to record only "well-marked" cases.

While Gruber associates the external supracondyloid tubercle with *M. plantaris*

[1] According to Hentzelt (*loc. cit.* SS. 27 and 31) Alfred Stieda in skiagram analysis of knee inquiries had several times found this process broken off in the living subject.

[2] The adductor tubercle is usually (and is usually figured) below the level of the insertion area of the internal head of *gastrocnemius*. On the other hand Gruber's process of the medial lip seems to us either above or at most on the same level as this insertion area.

Tuber supracondyloideum.

Material and Race	*Internum*					*Externum*				
	(I)	(II)	(III)	A	Totals	(I)	(II)	(III)	A	Totals
Gruber (Russian) ♂+♀, (R.+L.)	123 47·3 °/₀			137 52·7 °/₀	260 —	None	Fairly common		—	—
Hentzelt (German) ♂+♀, (R.+L.)	10 3·8 °/₀	118 [1]44·5 °/₀	45 17·0 °/₀	92 34·7 °/₀	265 —	0 0·0 °/₀	32 12·1 °/₀	44 16·6 °/₀	189 71·3 °/₀	265 —
Egyptian Naqada ♂, (R.+L.)	30 8·93 °/₀	130 38·69 °/₀	108 32·14 °/₀	68 20·24 °/₀	336 —	4 1·19 °/₀	37 11·01 °/₀	70 20·83 °/₀	225 66·96 °/₀	336 —
Ditto ♀, (R.+L.)	10 2·66 °/₀	120 31·91 °/₀	111 29·52 °/₀	135 35·91 °/₀	376 —	2 0·52 °/₀	9 2·34 °/₀	41 10·68 °/₀	332 86·46 °/₀	384 —
Ditto Unsexed, (R.+L.)	14 3·65 °/₀	135 35·16 °/₀	127 33·07 °/₀	108 28·12 °/₀	384 —	2 0·52 °/₀	20 5·24 °/₀	55 14·40 °/₀	305 79·84 °/₀	382 —
English (London) ♂, (R.+L.)	(i) 16 3·42 °/₀	(ii) 423 90·38 °/₀		(iii) 29 6·20 °/₀	468 —	(i) 4 0·85 °/₀	(ii) 235 50·21 °/₀		(iii) 229 48·93 °/₀	468 —
Ditto ♀, (R.+L.)	11 3·06 °/₀	323 89·97 °/₀		25 6·96 °/₀	359 —	1 0·28 °/₀	166 46·24 °/₀		192 53·48 °/₀	359 —

[1] This percentage appears to be erroneously given as 43 in Hentzelt's table, *loc. cit.* S. 35.

and Hentzelt with the external head of *M. gastrocnemius* as well as *M. plantaris*, we have often found it impossible to be certain of the limits of insertion of the two muscles on the bone taken alone. At any rate we have not been able to satisfy ourselves that the areas of insertion are as distinct or as definitely located as is indicated in some anatomical text-books, or at least that they can be thus clearly differentiated on all dead bones. Accordingly we have simply recorded a *tuber supracondyloideum externum*, where it occurs without venturing to associate it with *gastrocnemius* or *plantaris*. Indeed we almost gave up any record of this tubercle at all, it is so vague and unsatisfactory, and we lay no special stress on our results.

As a method of testing the assertion that muscularity is the essential factor in producing tubercles we have correlated the presence of the internal supracondylar tubercle with that of the third trochanter. We have the following tables for the Naqada femora:

Internal Supracondylar Tubercle	Male (R. + L.) Third Trochanter			Female (R. + L.) Third Trochanter		
	Present	Absent	Totals	Present	Absent	Totals
Present	106	121	227	98	113	211
Absent	19	39	58	37	70	107
Totals	125	160	285	135	183	318
Correlation ...	$r = +\cdot205 \pm \cdot069$			$r = +\cdot186 \pm \cdot060$		

Thus there is some small but definite association between the presence of the internal supracondylar tubercle and that of the third trochanter. But it is far from sufficiently large for us to argue from the presence of one to the presence of the other. Yet from the presence of tubercle and trochanter in very muscular bones and the absence of both in non-muscular bones, we might have anticipated a high correlation. Had it been large it would not have proved that muscularity is the source of tubercles, but it would not have told against that hypothesis. Association in presence might merely have indicated a link in evolutionary history. It may of course be argued that marked muscularity of the proximal may occur without equal muscularity of the distal end of the femur. At any rate the correlation is sufficient to suggest that it would be worth studying whether the internal supracondylar tubercle occurs in marked conjunction with the third trochanter in lower types than man. It appears to do so in the rabbit[1]. In

[1] See our Plate XXVII, fig. (IV), where this tubercle is visible, but not very adequately from the posterior aspect. In fig. (IV) the draughtsman has only given the depressions between the *gastrocnemius* protuberances, which are very marked in the original.

Dasypus sexcinctus there is almost a "Gruber's Process" towards the limit of the area of insertion of the internal head of *gastrocnemius*, it appears too high above the condyle to be looked upon as an exaggerated adductor tubercle[1]. We may thus attribute the association to reversion with as much logic as to muscularity.

(vi) *Poirier's Facet.* The first anatomist to lay adequate emphasis on this facet of the neck of the femur, as far as we have been able to ascertain, was Poirier[2]; it appears in his *Traité d'Anatomie humaine* of 1892. At any rate Poirier named it as the "empreinte iliaque," and French anatomists, and German writers following them, have attributed the interest aroused in the facet to him. Bertaux[3] in the previous year, 1891, refers to an extension of the articular surface on to the neck and states (p. 19): "Nous avons cherché la signification de cette empreinte; elle donne insertion à un très fort trousseau fibreux de la capsule articulaire." Poirier was in 1894 "Chef des travaux anatomiques à la Faculté de Médecine" in Paris, and his pupil Evangeli-Tramond, writing in 1894[4], attributes the first consideration of the subject to Poirier. He rejects the view of Bertaux, and substantiates on a larger number of subjects than Poirier himself had done that this surface is covered by a thin sheet of cartilaginous tissue similar to the cartilage of the femoral head. Referring to the fact that the facet may be either separated or united to the head, he continues:

Quand l'empreinte était isolée son cartilage était séparé de celui de la tête par une bandelette osseuse recouverte de son périoste, quand des deux surfaces se trouvaient réunies, la même nappe cartilagineuse s'étendait sur l'une et l'autre sans distinction[5].

Tramond adopts Poirier's suggestion that the facet arises from all the movements in which the femur is extremely bent on the pelvis. In order to realise the facet, however, we are told that the acetabulum must be sufficiently deep and the anterior face of the neck almost at the level of the cartilaginous surface of the head[6]. Thus the facet is attributed to exceptional use under exceptional osseous conditions. But why should this extension of the cartilaginous surface be any more the result of use than the production of the cartilaginous surface of

[1] See our Plate XXVII, fig. (III) for *Dasypus*.

[2] Bibl. 55, pp. 210 and 220.

[3] Bibl. 52, pp. 114 and 119.

[4] Bibl. 65, p. 61. Rudolf Fick (Bibl. 92, S. 318) also attributes to Poirier the first description, although he states that Henle indicates the facet in his diagram of the femur. The same remark, however, applies to the diagram of the femur in Quain's *Anatomy*, where Lawrence has clearly indicated the presence of the facet in a drawing of 1890 of the head and neck (see our Plate I). But the earliest reference to the facet is that of Henke (Bibl. 8, S. 205) who wrote of the articular surface of the head in 1863:

Am oberen lateralen Rande geht auch die überknorpelte Fläche oft noch ein Stück auf den Hals über, der dann hier nicht kugelig aber doch auch in der Richtung von hinten zu vorn convex gebogen ist.

But this does not suffice to give Henke a substantial claim as against Poirier. In German the "empreinte iliaque" of Poirier has been rendered as "Darmbeineindruck," or "Halsgelenkhöcker" (*Eminentia articularis colli femoris*).

[5] *Loc. cit.* p. 63.

[6] *Loc. cit.* pp. 64—5.

the head itself? Is that also supposed to be the result of use and not of specialised cell growth? The question is of considerable interest because in the rabbit and armadillo and in other cases the articular surface extends normally, not exceptionally, right onto the neck, reaching practically to the great trochanter. Thus we are either bound to assert that in these cases an area without any internal boundary is produced from $\frac{1}{4}$ to $\frac{1}{3}$ by use, and the remainder by specific inheritance, or else to assume that the whole area is due to a common cause, use or specific inheritance. But if this be so in the case of these animals, it seems idle to press the use origin of facets in man, unless we attribute to the same cause the whole area covered by the cartilaginous surface. Naturally even if the explanation were specific inheritance we should anticipate that the facet would be at the same time associated with variations, as Tramond suggests, of both the neck of the femur and of the acetabulum. What we question, having regard to the very wide prevalence of the facet, is any need for habitually exaggerated movements in addition to special variation of femur, neck and acetabulum; but given these, how can we be certain that they do not themselves connote an extension of the cartilaginous tissue, or that the facet is a product of usage at all?

In the case of man to attribute this facet to *exaggerated* movements appears to be idle[1], because Sudeck[2] found in examining a large number of femora that the facet was practically always present, and Fick[3] found it in 73 out of 80 femora examined. We consider that here again the percentage is largely a matter of personal equation, of the state of preservation of the bones under consideration, and of the markings which are included under the term facet. We have ourselves formed grades and categories of markings which may be considered under the head of facet of the neck or Poirier's facet. In the Appendix C, *A* stands for absence of the facet, when it occurs in the column headed Poirier's Facet; *d* stands for a bone in which the neck is so damaged that determination is impossible. Our first category, indicated by *a*, includes those cases in which there is unbroken prolongation of the articular surface on to the anterior face of the neck[4]. Where prolongation is very pronounced, we frequently find lipping of the articular margin just above the prolongation[5]. The prolongation is usually at the uppermost part of the anterior face of the neck, where it joins the superior surface. We have the

[1] Poirier recognises in general as the cause of the facet "tous les mouvements dans lesquels la cuisse est extrêmement fléchie sur le bassin, la cuisse étant plus ou moins en abduction" (Bibl. 65, p. 64). Tramond sums up by saying that: "l'empreinte iliaque est due au frottement de la partie antéro-supérieure et interne du col contre le renflement du bourrelet cotyloïdien sousjacent à l'épine iliaque antéro-inférieure, que la surface de l'empreinte est proportionnelle à la saille du renflement, et qu'enfin l'empreinte sera soit isolée, soit à peine tangente, soit en partie confondue avec la surface articulaire de la tête suivant que celle-ci sera peu étendue, ou au contraire empiétera beaucoup sur la face antérieure du col" (p. 66).

[2] Zur Anatomie und Aetiologie der *Coxa vara adolescentium* in the *Archiv für klinische Chirurgie*, Bd. LIX. S. 504—524, especially 509. Berlin, 1899.

[3] Bibl. 92, S. 318.

[4] W. 209, W. 303 and W. 311 are fully developed examples.

[5] W. 311, W. 169, and W. 358.

impression that such prolongation is usually found in rather strong and heavy bones.

β, our second category, includes facets of excavation type. These really fall into two classes. In the first there appears to be an excavation, but it may only be apparent and due to the raised ridge at its margin—the "bourrelet osseux" of Poirier[1]; these "excavations" are situated in the same position as the facet proper, and would perhaps be properly included in that category[2]. The second kind of "excavation[3]," which is perhaps more suitably described as such, is usually situated somewhat lower down on the anterior surface of the neck, and is more usually found in the more lightly-built bones. It has almost the appearance of an ulcer with sharply defined edges frequently undercut[4], and one of its chief peculiarities is that on the floor of the excavation the cancellous tissue is frequently exposed. When this occurs we have described it as an "erosion[5]." We believe that it is possible that there is an association between this "erosion" and the theory of Sudeck[6] that Poirier's facet is the "äussere Betonung einer besonders starken Spongiosastelle im Innern[7]." The distinction between the two classes of category β has been noted in the remarks to the measurements in Appendix C, where the "erosion" facets are marked β_r.

Lastly, under category γ we include the facet proper. We have applied this term to the rough impression situated on the anterior face of the neck, which, whilst it may reach as high up as the "prolongation," also may extend very much lower down[8]. It is usually rough and limited by a definite ridge which runs roughly parallel with the anterior intertrochanteric line[9].

We have classified under one heading the facet proper, the prolongation and the two types of excavation[10], not because we consider that they are necessarily all due to one source, but because the various authorities in discussing the facet appear to refer first to one and then to another of our types. One, two or even three phases of our facet may occur on the same bone, and we have noted these occurrences individually and in combination. The following tables give our results:

[1] Bibl. 80, p. 231. Note C.

[2] Illustrations are W. 443, W. 446 and W. 569.

[3] Illustrations are W. 139, W. 634, W. 692 and W. 694.

[4] For example, W. 694.

[5] All we mean by this is that *in appearance* it has something of the nature of an erosion; we do not associate the word with any dogma as to origin, or with the erosion which occurs in arthritic bones.

[6] *Loc. cit.* (p. 91) S. 509—510.

[7] Walkhoff (Bibl. 91, in his Figs. 10 and 13 especially) seems to show by his skiagrams that the spongiosa in the neighbourhood of the facet is to some extent differentiated. See also Sudeck's Tafeln XI—XIII.

[8] *E.g.* W. 177.

[9] See W. 63, W. 622 and W. 657.

[10] Actually in Appendix C we add I to α, β, or γ when that particular facet is very well marked, and III when it exists only slightly.

Presence of Poirier's Facet (London Femora).

Bone	*d*	*a*	*β*	*γ*	*aβ*	*aγ*	*βγ*	*aβγ*	A	Total	°/₀ with Facet
♂ R.	27	39	46	61	14	20	2	3	27	212	87·3
♂ L.	33	41	66	44	9	29	6	1	26	222	88·3
♀ R.	36	11	58	34	5	3	7	0	33	151	78·1
♀ L.	27	9	80	34	7	1	3	2	31	167	81·4
Totals	123	100	250	173	35	53	18	6	117	752	84·4
°/₀ ♂	12·1	18·4	25·8	24·2	5·3	11·3	1·8	0·9	12·2	434	87·8
°/₀ ♀	16·5	6·3	43·4	21·4	3·8	1·3	3·1	0·6	20·1	318	79·9

Presence of Poirier's Facet (Naqada Femora).

Bone	*a*	*β*	*γ*	*aβ*	*aγ*	*βγ*	*aβγ*	A	Totals	°/₀ with Facet
♂ R. + L.	36 10·14 °/₀	48 13·52 °/₀	169 47·61 °/₀	2 0·56 °/₀	15 4·23 °/₀	15 4·23 °/₀	2 0·56 °/₀	68 19·15 °/₀	355 —	— 80·85 °/₀
♀ R. + L.	31 8·12 °/₀	143 37·43 °/₀	67 17·54 °/₀	0 0 °/₀	13 3·40 °/₀	6 1·57 °/₀	1 0·26 °/₀	121 31·68 °/₀	382 —	— 68·32 °/₀
Unsexed R. + L.	21 6·31 °/₀	108 32·43 °/₀	101 30·33 °/₀	1 0·30 °/₀	15 4·51 °/₀	7 2·10 °/₀	4 1·20 °/₀	76 22·82 °/₀	333 —	— 77·18 °/₀

Thus the facet appears to be rather less frequent in the older series of bones.

On the whole our conclusion does not differ very widely from that of Fick[1], who found 91·2 °/₀ with the facet, so that by adding all types together we are not in excess of his frequency. Parsons[2] gives for presence of the facet ♂ R. 79 °/₀, ♂ L. 79 °/₀, ♀ R. 58 °/₀, ♀ L. 67 °/₀. He does not, any more than Fick, define what he means exactly by the facet or differentiate its types. He agrees with us in indicating that it is less frequent in the female than in the male. Our numbers appear to suggest that it is slightly more frequent on the left than on the right side, a result shown by Parsons only, but in a more marked manner for the females. An examination of the percentages of our tables indicates at once what is the difference between the male and female bones. The females have a marked

[1] Bibl. 92, p. 318.

[2] Bibl. 111, p. 255.

absence of facets of the prolongation type (α) and a marked redundancy of facets of the excavation type (β). This confirms the rough impression of the recorders that the prolongation facet occurred chiefly in the stronger and heavier bones, and the "erosion" facet in the more lightly built bones. As 16·5 °/₀ of the English female bones were damaged so that the facet could not be determined as against only 12·1 °/₀ of the male bones, it seems possible that there may be really little difference in the total percentage of facets between male and female bones, although it is fairly certain that the males have greater frequency of the "prolongation" and the females of the "erosion" type. In view of the fact that at least four out of five femora have the facet, it seems idle to attribute it to exaggerated movements of the thigh-bone, least of all to any practice of squatting[1].

We have set ourselves the following further problems:

(a) Is the presence of the facet in any of its forms related to (i) the angle of neck and shaft, (ii) the primary index of the neck and (iii) the secondary index of the neck, *i.e.* the ratio of minimum horizontal diameter of neck to horizontal diameter of head?

(b) (i) Is its presence associated with greater or less pilastry or platymery? (ii) with the presence or absence of the third trochanter or of the hypotrochanteric *fossa*?

(a) (i) Is there association of Poirier's Facet with the angle of neck and shaft (collar or cervical angle)?

The data are provided in the following tables:

English Males (R. + L.). Collar Angle in degrees.

Class of Poirier's Facet	[2]112–113	114–115	116–117	118–119	120–121	122–123	124–125	126–127	128–129	130–131	132–133	134–135	136–137	138–139	140–141	142–143	144–145	146–147	148–149	Totals
α	1	1	—	1	1	7	9	9	11	8	14	6	4	2	5	1	—	—	—	80
β	—	1	2	1	5	6	9	6	10	9	17	16	5	5	6	3	2	1	—	104
γ	—	1	4	2	7	8	6	9	12	14	12	6	7	5	3	2	—	1	—	99
$\alpha\beta$	—	—	—	1	1	1	—	1	2	7	2	2	—	1	1	1	1	1	—	22
$\beta\gamma$	—	—	—	—	—	—	2	—	1	1	1	1	—	—	1	—	1	—	—	8
$\gamma\alpha$	—	—	—	—	2	2	7	3	—	5	8	6	6	2	2	—	—	—	—	43
$\alpha\beta\gamma$	—	—	—	—	1	—	—	—	—	1	—	—	—	—	2	—	—	—	—	4
A	—	1	—	—	2	2	4	3	5	6	6	5	2	1	1	4	2	—	1	45
Totals	1	4	6	5	19	26	37	31	41	51	60	42	24	16	21	11	6	3	1	405

[1] Were it needful—which we doubt—to find an habitual posture likely to produce by pressure Poirier's facet, we would suggest the lying full length on the side in bed, with the upper lower limb thrown forward as the most likely position to induce considerable pressure on the observed region of the facet in the under lower limb.

[2] 112—113 signifies all values including 112 up to and *under* 114.

English Females (R. + L.). Collar Angle in degrees.

Class of Poirier's Facet	[1]106–107	108–109	110–111	112–113	114–115	116–117	118–119	120–121	122–123	124–125	126–127	128–129	130–131	132–133	134–135	136–137	138–139	140–141	142–143	144–145	146–147	148–149	Totals
α	—	—	—	—	1	2	—	1	—	4	—	2	2	1	2	4	—	1	—	—	—	—	20
β	1	—	1	1	1	3	3	4	6	8	7	14	12	14	18	10	15	3	3	1	2	1	128
γ	—	—	—	3	2	1	1	4	5	5	13	8	5	8	2	3	2	2	—	1	—	—	65
$\alpha\beta$	—	—	—	—	—	—	—	1	1	2	1	—	1	1	2	2	—	1	—	—	—	—	12
$\beta\gamma$	—	—	—	—	—	—	1	—	—	1	1	3	—	1	1	2	—	—	—	—	—	—	10
$\gamma\alpha$	—	—	—	—	—	—	—	1	—	—	—	1	1	—	—	—	—	—	—	—	—	—	3
$\alpha\beta\gamma$	—	—	—	—	—	—	—	—	—	—	1	—	—	—	1	—	—	—	—	—	—	—	2
A	—	—	—	—	—	2	2	4	8	5	6	7	8	3	5	8	2	2	—	2	—	—	64
Totals	1	—	1	4	4	8	7	15	20	25	29	35	29	28	31	29	19	9	3	4	2	1	304

We have found the mean collar angle for all femora showing sign of α-facet (*i.e.* $\alpha + \alpha\beta + \alpha\gamma + \alpha\beta\gamma$) and for all showing sign of β-facet, for γ-facet and for those in which there is an absence of facet. Placed in order of size we have for these means:

Male Femora	Female Femora
$m_A = 132°{\cdot}24 \pm {\cdot}73$	$m_\beta = 131°{\cdot}22 \pm {\cdot}40$
$m_\beta = 131°{\cdot}79 \pm {\cdot}39$	$m_A = 129°{\cdot}61 \pm {\cdot}56$
$m_\alpha = 130°{\cdot}92 \pm {\cdot}34$	$m_\alpha = 129°{\cdot}54 \pm {\cdot}75$
$m_\gamma = 130°{\cdot}34 \pm {\cdot}35$	$m_\gamma = 128°{\cdot}20 \pm {\cdot}50$

We have for the most marked differences:

Male	Female
$m_A - m_\gamma = 1°{\cdot}90 \pm {\cdot}81$	$1°{\cdot}41 \pm {\cdot}75$
$m_\beta - m_\gamma = 1°{\cdot}45 \pm {\cdot}52$	$3°{\cdot}02 \pm {\cdot}65$

It would thus appear that in the case of the "excavation" or β-facet the collar angle may be greater than in the case of an ordinary or γ-facet. But the significance is somewhat lessened by the absence of facet being more closely associated with the β- than with the γ-facet.

(α) (ii) Is there association between the index of the neck and the presence of the facet? The following means flow from the Table on p. 96:

	Males	Females
Mean Index of Neck ...	75·71	76·97
Facet Present	75·79	77·02
Facet Absent	75·17	76·78

[1] 106—107 signifies all values including 106 up to and under 107.

Index of Neck (R. + L.).

	Poirier's Facet	59–60	61–62	63–64	65–66	67–68	69–70	71–72	73–74	75–76	77–78	79–80	81–82	83–84	85–86	87–88	89–90	91–92	93–94	95–96	97–98	Totals
♂	Present	—	1	2	6·5	25·5	21	46·5	53·5	54	43·5	49·5	24	17·5	13·5	4	1	3	1	—	—	367
	Absent	1	—	1	3	2·5	3·5	6	3·5	8·5	6·5	7·5	4	—	3	—	—	1	—	—	—	51
	Totals	1	1	3	9·5	28	24·5	52·5	57	62·5	50	57	28	17·5	16·5	4	1	4	1	—	—	418
♀	Present	1	0·5	3·5	1	6	15	20·5	32·5	27·5	37	43	14·5	21	8	8	1	1	—	1	—	242
	Absent	—	—	—	1	1·5	4·5	5	10	8·5	11·5	8	2	5	3	1	—	—	—	1	—	62
	Totals	1	0·5	3·5	2	7·5	19·5	25·5	42·5	36	48·5	51	16·5	26	11	9	1	1	—	2	—	304

In both the sexes the neck index is very slightly higher when the facet is present, *i.e.* the more circular the neck, the greater intensity of the facet. But the probable error of the mean of the short series with facet absent is $\pm$ ·5, and accordingly it is very hard on the basis of these results to assert definite relationship of the absence of the facet to ellipticity of the neck. We worked out the correlation between ellipticity of neck and the intensity of the facet and found for biserial r:

$$\text{Males} \quad r = -\cdot 060 \pm \cdot 053;$$

$$\text{Females} \quad r = -\cdot 025 \pm \cdot 055.$$

It will be seen that these correlations although both negative have no significance, having regard to their probable errors.

(*a*) (iii) It seemed possible, however, that a more important factor than the shape of the neck might well be its size relative to the size of the head. Accordingly we formed a new index, taking as its measure the minimum horizontal diameter of the neck divided by the horizontal diameter of the head with the usual factor of 100. This index is a rough appreciation of the slenderness of the neck relative to the head; and we might anticipate that, if this index were low, the facet, if due to pressure, would be less conspicuous. It is conceivable that this index would also be of interest in comparing the femora of modern Europeans, primitive man and the anthropoids. We term it the Secondary Neck Index or Neck-Head Index to distinguish it from the more usual Primary Index of the Neck or the Ellipticity of the Neck.

The table on p. 97 provides the following results:

	Males	Females
Mean Secondary Neck Index ...	55·26	55·53
Facet Present	55·45	55·57
Facet Absent	53·89	55·38

The biserial correlations are: $+ \cdot 246 \pm \cdot 056$, $+ \cdot 033 \pm \cdot 059$.

Neck-Head Index (R. + L.).

Poirier's Facet		41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	Totals
♂	Present	—	—	—	—	—	1	·5	2	6·5	10·5	14·5	22	25·5	33	40·5	42	35·5	25·5	16	12·5	7·5	8·5	1·5	1	—	—	1	1	308
	Absent	—	—	—	—	1	1	—	3	1	1	3	4·5	4·5	4·5	5·5	4	4	3	2	1	—	1	—	—	—	—	—	—	44
Totals		—	—	—	—	1	2	·5	5	7·5	11·5	17·5	26·5	30	37·5	46	46	39·5	28·5	18	13·5	7·5	9·5	1·5	1	—	—	1	1	352
♀	Present	1	—	—	—	1	1	—	—	2	7·5	8·5	11·5	16	31	24	15·5	25·5	19·5	15	11·5	6	2	2·5	2	—	—	—	—	203
	Absent	—	—	—	—	—	—	·5	·5	1	·5	2·5	3	3·5	16	5·5	4	4·5	4·5	3·5	2·5	2·5	·5	1	—	—	—	—	—	56
Totals		1	—	—	—	1	1	·5	·5	3	8	11	14·5	19·5	47	29·5	19·5	30	24	18·5	14	8·5	2·5	3·5	2	—	—	—	—	259

Now these results are remarkable; there is a significant difference between the mean values of the neck-head index in the cases of facet present and facet absent in the males—none in the females. The correlation if small in the male is sensible, having regard to its probable error; it is insensible in the females. We have therefore to discover, if possible, some explanation of this anomaly.

We have shown on p. 91 that in our opinion there are at least three classes of facet; α the prolongation facet, β the excavation facet, and γ the true impress facet, a rough surface usually bounded by a definite ridge, which is separated from the articular surface of the head and the floor of which is not excavated. Combinations of these facets may exist side by side in the same bone. We accordingly regrouped our material, finding the mean of both primary and secondary neck indices for the categories α, β, γ; here we understand by α all the categories containing α, or $\alpha = \alpha + \alpha\beta + \gamma\alpha + \alpha\beta\gamma$, and similarly $\beta = \beta + \alpha\beta + \beta\gamma + \alpha\beta\gamma$, $\gamma = \gamma + \alpha\gamma + \beta\gamma + \alpha\beta\gamma$. The tables on p. 98 were obtained.

The means of the rows give the following results where m_T = mean of total:

Ellipticity of Neck

♂	♀
$m_\beta = 75{\cdot}91$	$m_\alpha = 77{\cdot}39$
$m_{\alpha+\beta+\gamma} = 75{\cdot}60$	$m_\beta = 77{\cdot}13$
$m_T = 75{\cdot}56$	$m_{\alpha+\beta+\gamma} = 77{\cdot}06$
$m_\alpha = 75{\cdot}53$	$m_T = 77{\cdot}01$
$m_\gamma = 75{\cdot}41$	$m_A = 76{\cdot}78$
$m_A = 75{\cdot}17$	$m_\gamma = 76{\cdot}76$

Neck-Head Index

♂	♀
$m_\alpha = 55{\cdot}89$	$m_\alpha = 56{\cdot}16$
$m_{\alpha+\beta+\gamma} = 55{\cdot}34$	$m_\beta = 55{\cdot}85$
$m_\gamma = 55{\cdot}29$	$m_{\alpha+\beta+\gamma} = 55{\cdot}69$
$m_T = 55{\cdot}19$	$m_T = 55{\cdot}63$
$m_\beta = 54{\cdot}81$	$m_A = 55{\cdot}38$
$m_A = 53{\cdot}89$	$m_\gamma = 55{\cdot}13$

Now an examination of these means shows that the ellipticity of the neck has very little influence at all on the presence of the facet. The presence of the simple type of facet (γ) gives no sensible difference in the mean ellipticity of the neck from the absence of facet. m_α and m_β are higher than m_γ and m_A for both sexes, but we may doubt whether this has any solid significance. All we can say is that prolongation and excavation types of facets occur rather more frequently on femora with more circular necks, but the significance is very, very slight. Turning now

Ellipticity of Neck (R. + L.)[1].

Nature of Facet	59–60	61–62	63–64	65–66	67–68	69–70	71–72	73–74	75–76	77–78	79–80	81–82	83–84	85–86	87–88	89–90	91–92	93–94	95–96	Totals
♂ α	—	1	2	4	10	10	18	18·5	24·5	22	22	6	7·5	4·5	2	—	1	1	—	154
♂ β	—	1	—	1·5	10·5	6	18	23·5	19·5	15·5	21·5	9	4	5	2	—	3	—	—	140
♂ γ	—	—	1	5	12	11	20	26·5	19·5	17	16	13	9·5	6·5	1	1	—	—	—	159
♂ A.	1	—	1	3	2·5	3·5	6	3·5	8·5	6·5	7·5	4	—	3	—	—	1	—	—	51
Totals	1	2	4	13·5	35	30·5	62	72	72	61	67	32	21	19	5	1	5	1	—	504
♀ α	1	—	1	—	—	1	2	—	4	9	14	1	1	1	1	—	—	—	—	36
♀ β	—	·5	2·5	1	3	11	10·5	22·5	16·5	27	27·5	10	11	7	4	1	1	—	1	157
♀ γ	1	—	1	—	4	6	8	11	9	7	9·5	5·5	10	5	3	—	—	—	—	80
♀ A.	—	—	—	1	1·5	4·5	5	10	8·5	11·5	8	2	5	3	1	—	—	—	1	62
Totals	2	·5	4·5	2	8·5	22·5	25·5	43·5	38	54·5	59	18·5	27	16	9	1	1	—	2	335

Neck-Head Index (R. + L.).

Nature of Facet	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	Totals
♂ α	—	—	—	—	—	—	·5	·5	1	4·5	3·5	7·5	8·5	14·5	18·5	23	19	10	6	4	3	5	1	—	—	—	1	1	132
♂ β	—	—	—	—	—	—	—	1·5	2·5	8	7·5	10	14	13·5	15·5	15·5	10·5	8·5	3	4·5	2·5	3	—	—	—	—	1	—	121
♂ γ	—	—	—	—	—	1	·5	·5	3	6	5·5	8	10	14·5	16·5	16	15·5	10	8	5	4	1·5	·5	1	—	—	—	—	127
♂ A.	—	—	—	—	1	1	—	3	1	1	3	4·5	4·5	4·5	5·5	4	4	3	2	1	—	1	—	—	—	—	—	—	44
Totals	—	—	—	—	1	2	1	5·5	7·5	19·5	19·5	30	37	47	56	58·5	49	31·5	19	14·5	9·5	10·5	1·5	1	—	—	2	1	424
♀ α	—	—	—	—	—	—	—	—	1	—	1·5	2·5	—	3	6	1·5	4·5	7·5	4·5	1	1	—	—	—	—	—	—	—	34
♀ β	—	—	—	—	1	1	—	—	—	3·5	7·5	7·5	11	17·5	14·5	10	16	9·5	11	8·5	5	2	2·5	2	—	—	—	—	130
♀ γ	1	—	—	—	—	—	—	—	1	4	2·5	3·5	5	14	5	5·5	8·5	5	6	4	2	—	—	—	—	—	—	—	67
♀ A.	—	—	—	—	—	—	·5	·5	1	·5	2·5	3	3·5	16	5·5	4	4·5	4·5	3·5	2·5	2·5	·5	1	—	—	—	—	—	56
Totals	1	—	—	—	1	1	·5	·5	3	8	14	16·5	19·5	50·5	31	21	33·5	26·5	25	16	10·5	2·5	3·5	2	—	—	—	—	287

A. = Absent.

[1] The totals in these tables will not agree with the totals of that on p. 92, partly because of the difference of categories, but mainly because we are here confined to cases in which it was possible to take certain measurements of both neck and head.

to the neck-head index we notice that there is irregularity with regard to the position of m_β and m_γ in the male and female series, but that in both cases the prolongation facet stands at the head of the series, and the bones without facet practically at the bottom. It would seem therefore that such correlation as exists between the secondary neck index and the presence of the facet is largely due to the prolongation type. We accordingly worked out the correlations between the presence of the prolongation facet and the neck-head index and found[1]:

$$\text{Males} \quad r = + \cdot 184 \pm \cdot 035 ;$$
$$\text{Females} \quad r = + \cdot 116 \pm \cdot 041.$$

Thus the female correlation has been very considerably increased, the male somewhat decreased, by concentrating our attention on the prolongation facet. The reason of the previous difference between the male and female correlations is now clear. The males have 37·5 °/₀ of cases with the prolongation facet, the female only 13·1 °/₀. Thus by including all parts we should weaken the female correlation more than the male. At the same time there are so few males with an apparent absence of facet, 12·2 °/₀ as against 20·1 °/₀ of females, that a sampling error in this group will readily account for the reduction of male correlation, when we isolate the prolongation facets of the males. To sum up we find no such *marked* association between shape of neck and presence of the facet, as we should have anticipated had it been due to posture. There is a *slight* relation between the presence of a prolongation facet and the anterior face of the neck being more nearly on the same level as the anterior face of the head. This is not necessarily an argument that use produces the prolongation, for the very idea of prolongation of the articular surface of the head suggests a neck along which it can be prolonged. That a high neck-head index is not usually associated with a prolongation facet is shown by examining the table in the footnote below; it will be seen that if indices over 57 be considered high only 31 out of 82 male femora and 14 out of 73 female femora with high neck-head indices have prolongation facets.

If, as the preceding discussion seems to show, the shape of the neck has but little

[1] The tables were as follows:

Neck-Head Index (R. + L.).

Prolongation Facet		41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	Totals
♂	Present	—	—	—	—	—	—	·5	·5	1	4·5	3·5	7·5	8·5	14·5	18·5	23	19	10	6	4	3	5	1	—	—	—	1	1	132
	Absent	—	—	—	—	1	2	—	4·5	6·5	7	14	19	21·5	23	27·5	23	20·5	18·5	12	9·5	4·5	4·5	·5	1	—	—	—	—	220
Totals		—	—	—	—	1	2	·5	5	7·5	11·5	17·5	26·5	30	37·5	46	46	39·5	28·5	18	13·5	7·5	9·5	1·5	1	—	—	1	1	352
♀	Present	—	—	—	—	—	—	—	—	1	—	1·5	2·5	—	3	6	1·5	4·5	7·5	4·5	1	1	—	—	—	—	—	—	—	34
	Absent	1	—	—	—	1	1	·5	·5	2	8	9·5	12	19·5	44	23·5	18	25·5	16·5	14	13	7·5	2·5	3·5	2	—	—	—	—	225
Totals		1	—	—	—	1	1	·5	·5	3	8	11	14·5	19·5	47	29·5	19·5	30	24	18·5	14	8·5	2·5	3·5	2	—	—	—	—	259

association with the presence of the facet, we may ask: Is it associated with other anomalies, which we certainly hold to be atavistic in character, or is it a purely human character of the femur?

In the first place we formed fourfold tables for the presence and absence of the third trochanter and the facet, combining R. and L. bones.

Poirier's Facet	Third Trochanter in Males			Third Trochanter in Females		
	Present	Absent	Totals	Present	Absent	Totals
Present ...	177	178	355	130	98	228
Absent ...	25	21	46	43	17	60
Totals ...	202	199	401	173	115	288

In both cases there is a correlation, small in the males, sensible in the females, between absence of the third trochanter and presence of the facet; tetrachoric $r = -\cdot059 \pm \cdot069$ and $-\cdot223 \pm \cdot069$ for males and females respectively. Similar tables were made up for the hypotrochanteric *fossa* and the facet:

Poirier's Facet	Hypotrochanteric Fossa in Males			Hypotrochanteric Fossa in Females		
	Present	Absent	Totals	Present	Absent	Totals
Present ...	137	241	378	61	186	247
Absent ...	25	26	51	12	50	62
Totals ...	162	267	429	73	236	309

In the case of the males the facet is more frequently absent when the *fossa* is present, but in the case of females it is more frequently present when the *fossa* is present. The correlations are respectively $r = -\cdot172 \pm \cdot066$ and $r = +\cdot102 \pm \cdot075$.

These results being very inconclusive we tested them further on the Naqada material. The corresponding tables were:

Poirier's Facet	Hypotrochanteric Fossa in Males (R. + L.)			Hypotrochanteric Fossa in Females (R. + L.)		
	Present	Absent	Totals	Present	Absent	Totals
Present ...	62	197	259	85	199	284
Absent ...	28	91	119	19	49	68
Totals ...	90	288	378	104	248	352

leading to $r = +\cdot008 \pm \cdot062$ and $r = +\cdot033 \pm \cdot068$.

We next dealt with the third trochanter and the facet of the neck in the Naqada femora and found:

Poirier's Facet	Third Trochanter in Males (R. + L.)			Third Trochanter in Females (R. + L.)		
	Present	Absent	Totals	Present	Absent	Totals
Present ...	112	145	257	120	157	277
Absent ...	46	70	116	24	42	66
Totals ...	158	215	373	144	199	343

leading to $r = +\cdot061 \pm \cdot058$ and $r = +\cdot102 \pm \cdot066$.

The correlations with Poirier's facet are accordingly in the case of both hypotrochanteric *fossa* and third trochanter quite insignificant.

Thus it would not appear that this facet on the neck of the femur in man is an atavism associated with forms in which either third trochanter or hypotrochanteric *fossa* are common. For example, the prolongation of the articular surface onto the neck is customary in the femur of the rabbit and the armadillo, and then is always accompanied by the third trochanter. Poirier's facet and the *trochanter tertius* in man do not appear to be associated in like manner[1].

We may now consider how the presence of the facet is related to such peculiarly human characteristics of the femur as pilastry and platymery.

Dealing first with the pilastric index, the tables for analysed nature of the facet are given on p. 102. Taken in order of size the means run:

Pilastric Index for various types of Poirier's Facet[2].

Means, Males	Means, Females
$m_\alpha = 103{\cdot}24$	$m_\gamma = 100{\cdot}16$
$m_\gamma = 104{\cdot}11$	$m_\alpha = 101{\cdot}09$
$m_T = 104{\cdot}19$	$m_T = 101{\cdot}32$
$m_\beta = 104{\cdot}35$	$m_\beta = 101{\cdot}69$
$m_A = 106{\cdot}97$	$m_A = 101{\cdot}97$

These results for the two sexes are in fairly good agreement; they show that the bones without facets have a higher average pilastric index than those with facets and that the bones with prolongation and excavation types have the lowest pilastric indices.

[1] We have correlated presence of *prolongation* facet (*i.e.* category α) with presence of third trochanter and find in the fourfold tables for both sexes that the association is *negative*. Of course in rabbit and armadillo the prolongation is more on the top and posterior than the anterior surface of the neck. Such prolongations occasionally occur in certain human femora, but we have not recorded them under Poirier's facet.

[2] Here again $\alpha = \alpha + \alpha\gamma + \alpha\beta + \alpha\beta\gamma$ and similarly for β and γ. m_T = mean of totals.

Pilastric Index (R. + L.).

Nature of Facet		65–68	69–72	73–76	77–80	81–84	85–88	89–92	93–96	97–100	101–104	105–108	109–112	113–116	117–120	121–124	125–128	129–132	133–136	137–140	141–144	145–148	Totals
Males	α	—	—	1	—	2	4·5	11·5	19·5	20·5	27	25·5	19·5	17	4	3·5	1·5	—	—	—	—	—	157
	β	—	—	—	2	1	1	9·5	13·5	21	28	21·5	14	18·5	8	3·5	1·5	—	—	—	—	—	143
	γ	1	—	—	1	2	5	12	14·5	19·5	30	24·5	20	25·5	7	1·5	1·5	—	—	—	—	1	166
	A.	—	—	—	—	—	1	3	3·5	8·5	3	6·5	11	8·5	2·5	0·5	2	1	—	—	—	—	51
	Totals	1	—	1	3	5	11·5	36	51	69·5	88	78	64·5	69·5	21·5	9	6·5	1	—	—	—	1	517
Females	α	—	—	—	1	—	2	5	4	5	10	3	2	2	2	—	—	—	1	—	—	—	37
	β	1	—	2	—	5	4·5	15·5	20	29	20	16	21·5	11·5	9	4	—	—	—	—	—	—	159
	γ	—	—	1	1	2	2	11	10·5	18·5	11	11	7	2	3	—	—	1	—	—	—	—	81
	A.	—	—	—	—	1	7·5	1·5	6	10	10	14	9	1	3	—	1	—	—	—	—	—	64
	Totals	1	—	3	2	8	16	33	40·5	62·5	51	44	39·5	16·5	17	4	1	1	1	—	—	—	341

If now the same material be treated in biserial tables, taking only facet present and absent, we find:

Pilastric Index (R. + L.).

Poirier's Facet		65–68	69–72	73–76	77–80	81–84	85–88	89–92	93–96	97–100	101–104	105–108	109–112	113–116	117–120	121–124	125–128	129–132	133–136	137–140	141–144	145–148	Totals
Males	Present	1	—	1	3	4	7·5	27·5	38	49	70	57	42	49	18	6·5	3·5	—	—	—	—	1	378
	Absent	—	—	—	—	—	1	3	3·5	8·5	3	6·5	11	8·5	2·5	0·5	2	1	—	—	—	—	51
	Totals	1	—	1	3	4	8·5	30·5	41·5	57·5	73	63·5	53	57·5	20·5	7	5·5	1	—	—	—	1	429
Females	Present	1	—	2	2	6	7·5	27·5	29·5	47·5	37	27	27·5	14·5	12	4	—	1	1	—	—	—	247
	Absent	—	—	—	—	1	7·5	1·5	6	10	10	14	9	1	3	—	1	—	—	—	—	—	64
	Totals	1	—	2	2	7	15	29	35·5	57·5	47	41	36·5	15·5	15	4	1	1	1	—	—	—	311

These tables give:

	Males	Females
Mean Facet Present	103·91	100·58
„ „ Absent	106·97	101·97

providing correlations of presence of facet and pilastric index of:

$$-\cdot167 \pm \cdot052 \quad \text{and} \quad -\cdot040 \pm \cdot054.$$

We now turn to the platymeric index and examine its relation to the facet in the same manner.

Platymeric Index (R. + L.).

Nature of Poirier's Facet		64–66	67–69	70–72	73–75	76–78	79–81	82–84	85–87	88–90	91–93	94–96	97–99	100–102	103–105	106–108	109–111	112–114	115–117	Totals
Males	α	—	5	7·5	8·5	13	23·5	28·5	25	16	13	6·5	2·5	2	3	2	1	—	—	157
	β	—	5	4	8	11	15	25·5	15·5	16	17	9	3	7	2	3	1	1	—	143
	γ	—	2	6	13	15·5	23·5	26	24·5	10·5	15	9·5	8·5	6	—	3	—	1	1	165
	A.	1	1	—	4	4	3	6	11	5	5	3	2	2	2	2	—	—	—	51
	Totals	1	13	17·5	33·5	43·5	65	86	76	47·5	50	28	16	17	7	10	2	2	1	516
Females	α	—	2	4	1	5	4	4·5	3·5	3	5	2	—	—	—	1	—	—	1	36
	β	2	1	10	14	25	24	26·5	12	14·5	15	2	4	—	1	3	1	—	3	158
	γ	1	2	3	10	14	13·5	15·5	9	4	3	2	—	1	1	1	—	—	—	80
	A.	—	1	7	6	7	10	8	7·5	4·5	3	3	2	3	1	—	1	—	—	64
	Totals	3	6	24	31	51	51·5	54·5	32	26	26	9	6	4	3	5	2	—	4	338

Platymeric Index for various types of Poirier's Facet.

Means, Male	Means, Female
$m_\alpha = 84{\cdot}19$	$m_\gamma = 81{\cdot}33$
$m_\gamma = 85{\cdot}26$	$m_T = 82{\cdot}86$
$m_T = 85{\cdot}32$	$m_\beta = 83{\cdot}27$
$m_\beta = 86{\cdot}07$	$m_A = 83{\cdot}28$
$m_A = 86{\cdot}88$	$m_\alpha = 83{\cdot}71$

Here the female data are very irregular, while the male data are very consistent and show that the presence of the facet is associated with lesser platymeric index. To obtain some final order we took biserial tables for presence and absence of facet and obtained the following results:

Platymeric Index (R. + L.).

Poirier's Facet		64–66	67–69	70–72	73–75	76–78	79–81	82–84	85–87	88–90	91–93	94–96	97–99	100–102	103–105	106–108	109–111	112–114	115–117	Totals
Males	Present	—	11	15·5	26·5	35	45·5	62	54·5	34	33	20	13	14	2	5	2	2	1	376
	Absent	1	1	—	4	4	3	6	11	5	5	3	2	2	2	2	—	—	—	51
	Totals	1	12	15·5	30·5	39	48·5	68	65·5	39	38	23	15	16	4	7	2	2	1	427
Females	Present	3	3	16	22	37	36	42·5	23	19·5	20	6	4	1	2	4	1	—	3	243
	Absent	—	1	7	6	7	10	8	7·5	4·5	3	3	2	3	1	—	1	—	—	64
	Totals	3	4	23	28	44	46	50·5	30·5	24	23	9	6	4	3	4	2	—	3	307

These give for the means of the platymeric indices:

	Males	Females
Facet Present	84·93	82·81
„ Absent	86·88	83·28

Thus in both cases the facet present is associated with the lower platymeric index, *i.e.* with the greater platymery, just as it was associated with the lower pilastric index. The correlations here are, however, slightly less, being:

Presence of Facet and high Platymeric Index.

For males $-\cdot115 \pm \cdot053$ and $-\cdot031 \pm \cdot054$.

To sum up a rather lengthy discussion which has been principally of a negative character: We have not found that the shape of the neck is intimately related with the presence of the facet, nor is its presence—as might be suggested from lower types of life—closely associated with the presence of a third trochanter, rather indeed with its absence. There is no consistent associative relation for both sexes with the hypotrochanteric *fossa*. The presence of the facet is slightly—not very significantly—associated with less pilastry and more platymery, which suggests, but nothing more, that the facet is connected with the more primitive bones and possibly with lower races and even types of life[1]. There is nothing in our results confirmatory of the view that it is essentially a product of habit or use. And were it due to use, then the type of use would have to vary with the numerous races in which it is found, and with the special category of facet occurring. It appears to us extremely unlikely that a prolongation facet and an excavation facet are really due to the same sources—only acting with greater intensity or on differently constituted bones.

(vii) *Charles' Facet.* Arthur Thomson in a paper of 1889[2] attributed facets developed on the anterior margin of the inferior articular surface of the tibia and on the neck of the astragalus, which come in contact with each other in extreme flexure of the foot on the leg to posture and use. He says that they are of rare occurrence in the higher races, and that the posture of squatting is habitual in the lower races. These facets, he concludes, are acquired, not transmitted. This conception of the influence of posture was taken up by Havelock Charles[3] in 1894. He refers to Poirier's facet of the neck and draws attention to another articular facet on the inner side of the upper surface of the internal condyle of the femur. This facet we propose for brevity to term *Charles' Facet.* He gives on p. 10 of his first memoir a figure of this facet, but the figure is by no means

[1] The pilastric index is low for the anthropoids (gorilla c. 75, orang c. 78, chimpanzee c. 85, gibbon, c. 97: see our Chapter VI.). The platymeric index is also low for the anthropoids (gorilla c. 81, orang c. 71, chimpanzee c. 83, gibbon c. 83). We have not had the opportunity of examining a large number of anthropoid femora, but we have found something akin to the γ-type facet in gorilla and chimpanzee; also we have found a similar facet in a large ♂ gorilla femur on the *posterior* face of the neck. The platymeric index is very low for Maori (♂ 64, ♀ 61) and Moriori (♂ 66, ♀ 64) according to Scott (Bibl. 62) and Mollison (Maori ♂ + ♀ 62, Bibl. 100). Similarly Neolithic Swiss, Row Grave Swabians, Ainos, Fuegians, Patagonians and ancient Indians of South America have low platymeric indices or a high degree of platymery. Costa (see our p. 71) found the *trochanter tertius* in 35 out of 37 Fuegian femora and the hypotrochanteric *fossa* in every case.

[2] Bibl. 49, particularly p. 632.

[3] Bibl. 66.

clear; we presume the facet is the narrow area which appears between the articular surface of the inner condyle and the base of the bursa[1]. Havelock Charles asserts that such facets are acquired and that no influence of heredity has been proved. Resemblance of modern savage to prehistoric man in regard to them is due to the influence of common habits (p. 18). These habits are those of squatting—*i.e.* sitting with the knees together and the buttocks on the heels, with the soles of the feet flat—or of the sartorial position—*i.e.* knees apart, legs crossed and the soles of the feet in vertical planes. Charles illustrates his ideas from Panjabi femora.

Unfortunately in the very same year, in a later page of the same volume of the journal[2], Charles had to modify his standpoint. He found in a foetus of the eighth to ninth month and in an infant of three months of Panjabi race[3] the occurrence of the facet on the internal condyle of the femur. Thus use is not needful for the development of the facet. He therefore, without questioning his original opinion that the markings are due to use, to the effect of certain muscles acting on the joints, assumes the occurrence of the facet in the infant to be a valid illustration of the transmission of acquired characters. The facets on the tibia and astragalus which he had noted in the Panjabi having been found in neolithic European remains, but not in the modern western types (according to Havelock Charles), is a sign that use inheritance being acquired can be again modified. His acceptance of the accumulating influence of use on inheritance appears complete:

> Want of use would induce changes in form and size, and so gradually small differences would be integrated till there would be a total disappearance of the markings on the European's skeleton, as no advantage would accrue to him from the possession of facets on his bones fitting them for postures not practised by him (p. 279).

And again:

> The facets seen on the bones of the Panjabi infant or foetus have been transmitted to it by the accumulation of peculiarities gained by habit in the evolution of its racial type, in which an acquisition having become a permanent possession "profitable to the individual under its conditions of life" is transmitted as a useful inheritance (p. 279).

We must confess that in the light of present evidence this is a heavy superstructure to rear until the statements that the markings are due to the influence of certain positions, which are rendered possible by the use of particular groups of muscles, and that they are the definite results produced by actions of those muscles[4] are established with less dogma and more demonstrative evidence. Unfortunately we find grave difficulty in the record of Charles' facet, because we are not certain that what we are registering corresponds to the phenomenon observed by Havelock Charles. His diagrams seem to us far from clear and do not provide any measure of the quantitative extent of the marking which he would record as a facet.

We have found the articular surface of the internal condyle on the trochlear

[1] *Bursa mucosa supracondyloidea (interna)* of Gruber (Bibl. 3 *bis*, S. 11 *et seq.*, Tafeln I—III), better *suprȧcondylaris*, which would also be more appropriate in the case of the tubercle: see our p. 86.

[2] Bibl. 67. [3] *Loc. cit.* Fig. 5, p. 277. [4] *Loc. cit.* pp. 279—280.

side of the superior surface to be prolonged towards the bursa almost invariably to a greater or lesser extent. To what extent must it be prolonged in order to be regarded as a Charles' facet? Our Plates XXII, XXIX and XXX show well-marked instances of the prolongation of the articular surface right up to the floor of the bursa[1]; it is well marked in about 1 °/₀ of bones[2], and is very generally present at least to some slight degree. Under the circumstances we have considered it better not to record presence and absence of this facet until we have dry Panjabi femora available for full comparison with European bones. It is more frequent in Egyptian than in English bones, but its existence in the latter is hardly compatible with its being due to squatting, unless we extend the principle of the inheritance of acquired characters, and then it ceases to be possible to assert when acquirement by posture really begins.

(viii) *External Fossette of the Anterior Face.* This anomaly has been especially recorded by Bello y Rodriguez[3], and he lays considerable stress upon it as differentiating European from American (Indian) races. The phenomenon consists of a small *fossa* or trough running down the external side of the anterior face of the femur. We have noted its presence only, and then to merely some slight extent, in W. 667. It occurs more frequently in Egyptian bones; see our Plates XXXIV and XL and may appear in association with a crural trough: see Plate XLI. Rodriguez himself says that he has noted it only as a faint trace (*à l'état d'ébauche*) in four out of 56 French males and in no case among 16 females. On the other hand it was nearly always present in the Cro-magnon femora, and in neolithic femora the following distribution was found:

External Fossette of Anterior Face.

Sex	Totals	Well-marked	Moderate	"à l'état d'ébauche"	Absent	°/₀ Present
♂	153	2	8	20	123	19·6
♀	71	0	9	16	46	35·2

Among the Polynesians Rodriguez found it six times fairly well marked and sixteen times feebly marked (58 °/₀) in 38 femora. Among 48 Negro femora it did not occur once. Among 75 Peruvians in 29 °/₀ of cases (although chiefly *à l'état d'ébauche*); it was, however, more frequent and of more marked character among Californians, Patagonians and Bolivians. We have not been able to compare our English material in this respect with any other race than the Naqada. We are not aware of any groove of the anterior face customary in lower types of life with which this human anomaly of the femur may be compared. We have, however, noted something of the kind in the femur of a sloth, and *à l'état d'ébauche*, associated with a slight crural trough in the femur of a beaver.

[1] The position of the facet makes it almost impossible to photograph it successfully.

[2] Illustrations are W. 565, W. 579, W. 580, W. 379, W. 527, L.S. 43, etc.

[3] Bibl. 101.

(ix) *Subtrochanteric Lateral Protrusion of the Anterior Face* ("Déviation supéro-externe de la face antérieure" of the French writers). We think this anomaly might well be spoken of as the platymeric protrusion. The phenomenon is a fairly frequent and marked one, although it appears to us to be associated in certain cases with diseased or feeble types of femora. This protrusion, looking at the bone from the anterior aspect, is indicated by a more or less marked bulge of the face to the lateral side in the subtrochanteric region. In the cases we have observed it is of one or other of two types.

The one type appears to arise from a combination of three factors. In the first place there must be a more or less marked gluteal ridge or hypotrochanteric *crista*; in the second place there must be marked torsion of the *linea aspera* surmounted by this gluteal ridge, so that the whole appears to run round from the posterior to the lateral face of the bone; and, lastly, there must be marked platymery. It is as if the normal bone modelled in wax had been subjected to a heavy roller on the posterior face from its middle upwards, the gluteal ridge being bent over to the lateral face and marked platymery produced by one and the same operation: see our Plate XXXVIII.

Rodriguez speaks of this anomaly "qui est en fonction de la platymérie d'une part et de la torsion d'autre part[1]," but while the protrusion is in our experience generally associated with platymery, it is not associated with torsion in the ordinary sense. The most usual torsion of, say, the *left* femur is that of a right-handed screw about the shaft with its point proximal; such a screw motion would turn the gluteal ridge from the lateral towards the mesial side of the posterior face of the femur. The torsion, however, to which we refer is one that turns the gluteal ridge still further away from the mesial side towards and even on to the lateral face of the bone. It appears to us rather due to the *retorsion* or to a torsion of the gluteal ridge only, than to the torsion of the bone as a whole, which latter would have to be markedly negative to produce the effect observed.

The second type of protrusion in the subtrochanteric region is associated with bones with marked *fossa hypotrochanterica*. If we suppose a normal bone without *fossa* to be modelled in wax and a die of the form of the hypotrochanteric *fossa* pressed on its posterior face, then the material would give way on the lateral side, the *fossa* being nearer to that side, and would appear as a subtrochanteric lateral protrusion. Of course this is no explanation of the origin of the protrusion, but is merely a description of the appearance. Such bones are also usually platymeric.

Plates XXXVIII and XXXIX provide marked cases of subtrochanteric protrusion, L.S. 93, W. 109, W. 296 and W. 93. A slight case is L.S. 273, in which the protrusion is further down the shaft, and a second still slighter is W. 167, in which the phenomenon would hardly be noticed without handling the bone itself. The phenomenon is well marked in about 2 °/₀ to 3 °/₀ of English femora, and in slightly under half the cases is associated with a *fossa hypotrochanterica* rather than a *crista hypotrochanterica*, or third trochanteric ridge. Rodriguez, who has

[1] *Loc. cit.* p. 82.

observed the anomaly in fairly extensive series, gives among others the following results[1]:

Subtrochanteric Lateral Protrusion.

Race	Sex	Totals	Well-marked	Moderate	Feeble	Absent	°/₀ Present
French	♂	56	2	9	7	38	32·1
,,	♀	15	0	0	5	10	33·3
Negroes	♂ + ♀	48	7	12	12	17	64·6
Berbers and Guanches	♂ + ♀	82	21	22	23	16	80·5
Neolithic Bones	♂	102	28	37	20	17	83·3
,, ,,	♀	49	14	17	13	5	89·8

Rodriguez, without actual numbers, says that this lateral protrusion is well marked in Malays and Polynesians, and both well marked and frequent in South American Indians.

Here again without a definite standard it is almost impossible to compare the records of different observers. Our English well-marked cases are about equally frequent with Rodriguez's French cases. We should not, however, call it common in English femora, and its appreciation for the slight cases is subject to large personal equation. Rodriguez's numbers appear to indicate that it is far more frequent in primitive and prehistoric races[2]. The atavistic interpretations we have been able to find lie in those flat protrusions identical with or surmounted by the third trochanter in types like the rabbit (see fig. (IV), Plate XXVII), or in the flattening of the base of the great trochanter so familiar in the femora of birds[3].

The reader of the preceding pages on the chief anomalies of the human femur will easily understand that we have not been impressed by any evidence provided by the writers cited that these anomalies are directly due to habit or use. Still less can we accept a good deal of the argument used in favour of the view that the pilaster, the *trochanter tertius* or the *fossa hypotrochanterica* are the *product* of muscular development[4]. It may be perfectly true that where these things exist in a marked degree there the musculature is often present in a marked degree also. But to assert that two factors are associated is not to demonstrate the antecedence of either of them, and to state that the pilaster serves as a surface of insertion for the crural muscle is not to demonstrate that the pilaster is developed by developing crural musculature. We are aware that many first-class authorities express views that seem closely allied to the actual production in the individual of a third trochanter by a developing *gluteus maximus* or of a pilaster

[1] Bibl. 101, see pp. 52, 58, 70 and 88.

[2] It is said to occur in the six Cro-magnon femora.

[3] See Note at the end of this chapter, p. 113.

[4] We have found the *fossa* in several foetal femora.

by the crural muscle[1]. But we venture to doubt whether the proof is any more valid than the proof that facets are due to habits of posture.

(x) *Influence of Use on Bone Form, based on pathological Cases.* A more valid attempt at proof had been provided in 1900 by Paul-Boncour[2]. He compared femoral measurements on the sound and the sick side in the case of six to eight skeletons of individuals from the great Bicètre Hospital, who had suffered from infantile hemiplegia. The conception of method is suggestive, but the material is really too slender to serve as a basis for adequate conclusions.

Taking lengths, Paul-Boncour finds excess on the sick side for maximum length and maximum trochanteric length. Analysed, he has six cases only; in two the maximum lengths are equal, and in the other four the excess of the sick side only reaches in one case 1 mm. In the case of the maximum trochanteric length four sick bones are in excess, two in defect. The differences do not appear to us beyond those which frequently occur with healthy R. and L. bones; our author does not state the side of the sick and sound bones. If we take maximum oblique length, the sick side has excess in three cases, defect in two cases and equality with the sound in one case. If we take the oblique trochanteric length—on which the author lays considerable stress as uninfluenced by angle of neck and shaft—the sick side is less in four cases and greater, although by less difference, in two cases. There appears in this material no evidence to show that use had to any sensible extent modified the absolute size of the bone. The bones were next weighed, and here the first completely accordant result was obtained; in every case the bone on the paralysed side showed the less weight[3]. Paul-Boncour now passes to the neck. He found the capito-collar length less in all cases but one on the sick side, but in this case the difference was the greatest observed. He accounts for this excess by the existence of an exostosis on the neck of the sound femur. In height of neck the sound femur was 1 mm. to the good in seven cases and 2 mm. in the remaining case; in breadth of neck the sick were in excess in two cases, in defect in one case and in three cases there was equality. The only certain and noteworthy differences thus appear to us to occur in the capito-collar length—a length which it is by no means easy to measure effectively and the appreciation of which may well depend on the cervical or collar angle. In Paul-Boncour's Chapter VI this collar angle is considered for six skeletons:

Collar Angle.

Skeleton	A	B	C	D	E	F	Mean
Sound Limb ...	115°	132°	129°	122°	124°	123°	124°·2
Sick Limb.....	123°	143°	132°	134°	130°	123°	130°·8

[1] See *inter alios* Manouvrier, Bibl. 57, Antony and Rivet, Bibl. 97, p. 256 *et seq.*

[2] Bibl. 84.

[3] *Loc. cit.* p. 364.

Now for adults Rodet[1] has given the French mean as 130°, Charpy[2] 127° for ♂s and 128° for ♀s, while Rodriguez[3] gives 125° for ♂s and 128° for ♀s and Evangeli-Tramond[4] 124° for ♂s and 128° for ♀s. For children under ten years Charpy found the mean collar angle to be 129° (32 cases). The great divergencies of these results depend partly on small numbers and partly on differences of method: see our p. 117.

Now it will be seen that the sick limb on the average has a mean collar angle agreeing fairly well with that of childhood, while the sound limb gives a value corresponding to the minimum average value observed for the French male adult. Paul-Boncour attributes the difference to habitually greater pressure exerted on the sound side; that the sound bones of some individuals have greater collar angles than the sick bones of other individuals he attributes to greater activity and muscularity in those cases. He is not, however, wholly consistent in his reasoning, for while he supposes the angle on the sick side to be that of childhood, he writes[5]:

> En tout cas mes observations permettent d'affirmer que les différences entre l'angle cervico-diaphysaire d'un enfant et celui d'un adult sont de beaucoup supérieurs à 2°, chiffre généralement adopté.

But if this were so, why should he appeal to the more than usual pressure, muscular action and exercise to which the sound limb in the paralysed is subjected, as explanatory of the difference between the sound and sick limbs? The standard deviation of the collar angle is about 5° to 6°; hence the probable error of a mean based on six cases is about 1·5°, and it therefore would not be possible to assert that the difference found between two means, based on six cases each, has less than 2·1° for its probable error. Thus the observed difference of 6·6° may very well correspond to the 2° to 3° between infant and adult recognised by Humphry[6] and others to exist. In other words, the sick limb may not have altered to the *usual* extent during growth; there is not sufficient evidence to show that it has altered more, and to argue from this as to greater use producing greater changes. We do not feel that the data are adequate to do more than confirm the check to ordinary growth; they do not suffice to prove mechanical action modifying the sound limb.

In the same manner and on equally slender material Paul-Boncour shows that (i) with one exception out of six cases the vertical and horizontal diameters of the head are smaller on the sick side; (ii) the pilastric index is smaller on the sick side, eight cases no exception; (iii) with one exception the obliquity of shaft is less on the sound side; (iv) that in six out of eight cases[7] the platymeric index is greater on the sound side; (v) the distribution of popliteal indices is equally balanced, but while *mn* is $> mp$ (see Diagrams B and C, of our Plates II and III) in all the sound bones, it is less in two of the sick bones and in one of the six

[1] Bibl. 3. [2] Bibl. 36. [3] Bibl. 101, p. 47.
[4] Bibl. 65, pp. 82—5. [5] *Loc. cit.* p. 379. [6] Bibl. 45.
[7] Case C appears to be erroneously determined for the values given: antero-posterior diameter 24, transverse 28 provide a platymeric index of 85·7 not 116·6 as recorded.

bones $mn = mp$. Paul-Boncour draws attention to the resemblance of his femora in these cases to that of *Pithecanthropus erectus*; but while his popliteal indices in these cases are 77·5 and 71·8, that of *Pithecanthropus* is said to be 97·0. His cases correspond much more closely to the pathological cases cited by Manouvrier in dealing with this subject[1].

Paul-Boncour interprets (ii) to signify that the pilaster is developed by exercise, but it might equally well result from a check to growth in certain directions, which would account again for (i). Until the actual values of the pilastric and platymeric indices in childhood are better known, it seems impossible to draw any definite conclusions as to the mechanical influence of use on the femur from Paul-Boncour's data. Before Paul-Boncour, Regnault in 1897 (rediscussion in 1901)[2] had endeavoured to illustrate by pathological cases how use could produce differentiation in the two femora. Thus he cited Humphry and Charpy to prove that the collar angle can only be altered during growth, and he cited pathological states to show how weight thrown on one limb during growth leads to the used member having a reduced angle.

There is another point of present interest to us in Regnault's memoir. Referring to the facets of the femur, he defined two types of Poirier's facet which appear to agree with our α and γ[3]. He stated that in 30 prehistoric femora from Coppières he found the facet absent in six cases only, that in eleven cases it was represented by the rough area, and presumably in the remaining cases by the prolongation. If we remember that his sexes are mixed we must turn for comparison to our table on p. 93 and calculate out the percentages in the row of totals.

	Recent British (♂ + ♀)	Prehistoric from Coppières
Facet Absent	15·6 °/₀	15·4 °/₀
Ordinary Facet ($\gamma + \beta\gamma$)	25·4 °/₀	28·2 °/₀
Prolongation Facet (after Regnault)		56·4 °/₀
Our Prolongation Facet ($\alpha + \alpha\beta + \alpha\gamma + \alpha\beta\gamma$)	45·7 °/₀	59·0 °/₀
Our Excavation Facet β	13·3 °/₀	

We are not able to justify fully this comparison of our α and β types with Regnault's first or prolongation type, but these rough data as far as they are comparable do not show any markedly greater frequency of Poirier's facet in prehistoric man. The equality of absence of the facet in late and primitive man is, as far as it goes, evidence against the squatting habit having conduced to its production, and indeed of any local habit because these have changed so immensely. Regnault himself cites the appearance of Poirier's facet in modern white races as evidence against "squatting" as its cause. But he appears still to credit the facet and also the actual value of the collar angle with being influenced by use. He states,

[1] Bibl. 68. [2] See Bibl. 73 and 88.

[3] Bibl. 73, p. 536: (i) "l'empreinte iliaque offre une surface lisse polie analogue à celle qui recouvre la tête femorale"; and (ii) "souvent l'empreinte au lieu d'un surface articulaire lisse n'offre qu'une surface rugueuse et élevée par rapport à la surface du col. De sorte que dans ces cas on peut douter s'il existe une empreinte iliaque."

however, that it depends not only on use, but also on the form of the acetabulum[1]:

outre l'amplitudes des mouvements il faut tenir compte de la forme de la cavité cotyloïde. Les frottements de la tête dans la cavité diffèront suivant la profondeur de cette cavité et aussi suivant la forme du bourrelet cotyloïdien[2].

Regnault illustrates on fractured acetabula that the head may have the articular surface extended so that it is almost ellipsoidal rather than spherical, when the acetabulum has been elongated by the fracture. He refers to similar results under arthritic conditions, for when the arthritic growth is on the border of the acetabulum there may result an articular surface extending over the whole neck. Also extra capsular fractures may consolidate and extend the articular surface down the neck almost to the trochanteric ridge. Regnault asserts that in all skeletons in which the facet exists there is a corresponding accentuation of the iliac spine. He applies the same argument to the facet on the superior face of the internal condyle. He states that its existence in Europeans[3] shows that the extreme flexure of squatting cannot be its sole source, and he claims that the shape of the condyle itself plays also a rôle.

Now we have to note that Poirier's facet in one form or another appears in 84 °/₀ to 85 °/₀ of English femora, hence the anomaly to be explained is not really the presence but the absence of the facet; the accentuation of the iliac spine must, if it is to account for the facet, be the rule not the anomaly.

The explanation of Regnault therefore amounts to the statement that the human femora develops normally owing to its having a normal iliac spine. The main problem therefore turns on how far a normal bone develops owing to self-controlling determinants or owing to its juxtaposition to other bones. It is the same big and probably insoluble problem as arises when we attempt to argue that great muscularity "causes" massive ridges or trochanters, or is a source of the pilaster. Both must coexist for efficiency, but to determine their relative priority seems a vague and possibly idle investigation. Would any satisfaction arise from the statement that the shape of the articular surface of the femoral head of the rabbit or armadillo is "due to" the shape of the acetabulum? Would it not be equally valid to attribute the acetabulum to the femoral head or still wiser to assert that both had developed in association because the extension of the articular surface served a definite purpose in the organism? If a prolongation

[1] Bibl. 73, p. 537.

[2] Tramond had already stated that anthropoids having a shallow acetabulum do not show the facet. This is nearly if not wholly in accordance with our experience.

[3] Regnault writes: "Il faut, il est vrai, noter que chez eux [Europeans] la facette est généralement séparée du condyle par une ligne saillante. Dans les dissections que j'ai pu faire à l'École pratique de sujets où cette facette existait, j'ai remarqué que l'insertion du muscle jumeau interne était reportée au-dessus." Bibl. 73, p. 541. It is very desirable that drawings or photographs of Charles' facet showing its relation to the floor of Gruber's bursa and the insertion of *M. gastrocnemius* should be provided. We have only found Charles' facet as a prolongation of the articular surface towards and apparently onto the floor of Gruber's bursa.

facet in man be "due" to the shape of the acetabulum, how much is characteristic of the species, *i.e.* due to the hereditary determinants, how much to the shape of the acetabulum in the racially characteristic prolonged articular surface of the armadillo or of the screamer?

Shortly, we do not feel that at present there is any conclusive evidence to demonstrate a relation of the so-called anomalies of the femur either to posture or to exercise. The problem of origin is in our opinion simply a phase of the wider problem of associated growth, and we can conceive an enthusiastic Mendelian treating fossae, facets and third trochanters as Mendelian units and experimenting on their heredity. Except for their continuity of variation, we should raise less logical objection to his treatment than we do to the attitude of the posturists.

Note to Page 108. *On the Platymeric or Subtrochanteric Lateral Protrusion.* It is by no means easy and very possibly unnecessary to differentiate lateral protrusion in the subtrochanteric region from a lateral flattening of the base and mid-portion of the great trochanter. This is especially the case in the femora of birds. The protrusion is marked in the shag, awl parrot and *Spheniscus demersus*, but in one form or another may be found in wild duck, king-vulture, capercailzie, *Chauna derbiana* and many other birds. It is marked in the *Apteryx mantelli*, specially characteristic of *Echidna* and takes a quite peculiar form in *Ornithorhynchus*. It will be found in the femur of *Aelurodon saevus*, one of the Miocene *Canidae* figured by Cope in Plate CXIX of his *Tertiary Mammalia and Permian Vertebrata* (New York, 1916). Our Plate XLV indicates its occurrence in *Hylobates lar*. We are therefore inclined to describe its appearance in man as an atavism, although we are not prepared to assert that such atavisms are not frequently associated with pathological or at least physically inferior femora.

CHAPTER IV

THE TYPE OF THE ENGLISH FEMUR, ITS COMPARISON WITH THOSE OF OTHER RACES, AND THE INFLUENCES OF SIDE AND SEX

(i) *Type of the English Femur.*

The mean values with their probable errors for 29 length characters, 8 angles, and 33 indices for right and left femora in male and female, are given in our Tables I and II below. These specify fairly fully the character of the English femur and form the material on which comparisons and conclusions of this chapter are chiefly based. We shall discuss in another chapter the individual characters. All we need say here is that we have been led to determine rather more characters than seemed to us requisite, because in many cases previous writers have made selections differing from each other and it is only by catholicity that comparison is at all possible[1].

Nevertheless we have still to note the extremely *illusory character of comparative measurements* as far as racial data at present exists.

When we approach the means of absolute measurements fixing the racial type of the femur, it might be supposed that we were reaching safe ground for comparative purposes, but this, alas! is very far from the case. The three fundamental sources of difficulty arise from:

(*a*) *Absence of any universally accepted and therefore standardised methods of measurement.*

Many writers not only give a narrow list of measurements, but often do not state definitely what they have measured and how it has been measured. They will record that they have taken "the length of the femur," and only in the course of laborious comparative analysis, or by an indirect allusion, does one become convinced that they have taken the oblique length with a Broca osteometer. Or, they will merely record "the trochanteric length" without realising that it may be measured in at least three different manners. In other measurements no comparison is possible owing to variety of method in taking what is only nominally the same measurement. Thus in taking the platymeric antero-posterior diameter one takes it where it is least, another selects the platymeric

[1] How extreme are the difficulties may be judged from the fact that we could not in a number of cases determine how the authors had dealt with cases of negative torsion, whether in forming the mean they had taken it with or without regard to sign. We were thus compelled to form two means, the first with and the second without regard to sign.

TABLE I. *London Femora. Means—Absolute Measurements.*

	Page[1]	Characters	Reference Number[1]	Males				Females			
				No.	Right	No.	Left	No.	Right	No.	Left
					mm.		mm.		mm.		mm.
Chief Lengths	4	Maximum Length	(*a*)	218	446·771 ± 1·017	225	447·700 ± 1·003	171	410·114 ± 1·037	181	408·257 ± 1·055
	4	Trochanteric Length	(*b*)	187	426·064 ± 1·017	209	425·553 ± ·997	144	389·664 ± 1·019	163	388·534 ± 1·033
	4	Max. Troch. Length	(*c*)	183	435·088 ± 1·041	206	434·112 ± 1·033	140	397·590 ± 1·089	158	397·953 ± 1·075
	4	Oblique Length	(*d*)	202	444·351 ± 1·029	214	445·481 ± 1·020	161	406·425 ± 1·069	169	405·210 ± 1·085
	7	Troch. Oblique Length	(*e*)	173	423·546 ± 1·056	194	423·456 ± 1·040	136	385·544 ± 1·115	149	385·893 ± 1·076
	20	Capito-Collar Length	(*t*)	227	77·037 ± ·318	229	77·212 ± ·307	167	68·380 ± ·330	182	67·396 ± ·312
	20	Length of Shaft	(*u*)	227	377·980 ± ·933	229	376·203 ± ·935	167	347·883 ± 1·072	182	347·604 ± ·926
	20	Capito-Trochlear Length	(*v*)	227	432·397 ± ·998	229	432·142 ± ·965	167	394·351 ± 1·107	182	393·676 ± 1·006
Bust	7	Vert. Diam. of Head	(*f*)	204	47·059 ± ·136	212	46·769 ± ·130	151	41·123 ± ·114	168	40·765 ± ·104
	7	Hor. Diam. of Head	(*g*)	180	46·597 ± ·142	196	46·375 ± ·125	135	40·711 ± ·118	156	40·497 ± ·108
	23	Min. Hor. Diam. of Neck	(n_h)	225	25·747 ± ·099	235	25·609 ± ·090	164	22·758 ± ·090	186	22·466 ± ·087
	23	Min. Vert. Diam. of Neck	(n_v)	225	33·849 ± ·121	235	34·236 ± ·116	164	29·377 ± ·104	186	29·520 ± ·097
Shaft Diameters	7	Platymeric Ant. Post. Diam.	(*h*)	236	26·831 ± ·084	247	26·646 ± ·086	178	23·820 ± ·089	193	23·339 ± ·079
	7	Platymeric Trans. Diam.	(*i*)	236	31·678 ± ·129	247	31·524 ± ·118	178	28·573 ± ·130	193	28·684 ± ·111
	9	Pilastric Ant. Post. Diam.	(*k*)	237	29·534 ± ·100	250	28·674 ± ·103	185	26·051 ± ·101	196	25·163 ± ·102
	9	Pilastric Trans. Diam.	(*l*)	237	28·023 ± ·096	250	27·950 ± ·088	185	25·195 ± ·096	196	25·367 ± ·098
	9	Popliteal Length	(*n*)	230	121·120 ± ·751	243	122·350 ± ·670	181	112·000 ± ·751	192	110·255 ± ·772
	9	Popliteal Width	(*o*)	232	39·834 ± ·176	239	39·475 ± ·173	182	36·280 ± ·170	188	35·513 ± ·156
	12	Popliteal Dir. Ant. Post. Diam.	(*p*)	228	27·965 ± ·107	238	27·872 ± ·115	182	24·269 ± ·119	188	24·383 ± ·091
	12	Popliteal Obl. Ant. Post. Diam.	(*q*)	233	30·773 ± ·108	235	30·621 ± ·113	181	26·801 ± ·108	184	26·810 ± ·095
Condyles	17	Bicondylar Width	(*s*)	153	80·147 ± ·219	166	79·404 ± ·215	102	70·123 ± ·227	114	69·886 ± ·218
	18	Max. Length, Ext. Condyle	(σ_1)	196	62·787 ± ·153	193	62·091 ± ·151	140	56·411 ± ·156	143	55·826 ± ·145
	18	Max. Length, Int. Condyle	(σ_2)	203	62·110 ± ·169	215	62·004 ± ·159	153	55·568 ± ·158	162	55·555 ± ·159
	18	Oblique Length, Ext. Condyle	(σ_1')	207	61·846 ± ·144	209	61·048 ± ·145	147	55·804 ± ·148	152	55·167 ± ·128
	18	Ext. Condyle Hor. Band Radius	(β_1)	160	18·706 ± ·102	178	19·074 ± ·092	112	16·646 ± ·106	115	16·970 ± ·103
	18	Ext. Condyle Vert. Band Radius	(β_2)	165	20·873 ± ·094	180	20·775 ± ·087	120	18·529 ± ·100	121	18·427 ± ·096
Bowing	36	Diaphysial Subtense	(A_2)	234	6·570 ± ·080	242	6·407 ± ·077	172	5·776 ± ·090	189	5·689 ± ·080
	36	Diaphysial Chord	(A_1)	234	252·631 ± ·850	242	252·765 ± ·836	172	228·614 ± ·941	189	226·088 ± ·895
	36	Proximal Segment of Diaphysial Chord	(A_3)	234	93·552 ± ·803	242	97·816 ± ·874	172	90·853 ± 1·183	189	96·553 ± 1·069
Angles	22	Midtrochlear Angle	(ω_1)	227	7°·900 ± ·056	229	7°·807 ± ·055	167	7°·829 ± ·071	182	7°·648 ± ·066
	22	Angle at Centre of Head	(ω_2)	227	42°·071 ± ·252	229	41°·061 ± ·245	167	43°·031 ± ·317	182	42°·439 ± ·316
	20	Collar Angle	(*w*)	227	130°·404 ± ·299	229	131°·474 ± ·290	167	129°·393 ± ·371	182	130°·280 ± ·371
	23	Torsion of Shaft	(x_1)	208	21°·760 ± ·564	211	26°·733 ± ·560	151	22°·050 ± ·691	165	28°·761 ± ·611
	30	Torsional Angle†	(x_2)	199	11°·628 ± ·421	210	14°·707 ± ·427	151	14°·242 ± ·558	162	17°·895 ± ·515
	30	Retorsional Angle	($x_2 - x_1$)	193	9°·733 ± ·523	196	12°·727 ± ·415	140	8°·072 ± ·562	153	10°·389 ± ·416
	30	Obliquity of Shaft	(*y*)	218	8°·686 ± ·092	233	11°·592 ± ·084	166	9°·392 ± ·112	175	11°·771 ± ·096
	31	Pseudo-Obliquity	(*z*)	203	[5°·97]	214	[5°·65]	159	[7°·93]	167	[6°·93]
	23	†Torsional Angle Disregarding Sign	—	199	12°·103 ± ·388	210	14°·979 ± ·406	151	14°·864 ± ·510	162	17°·920 ± ·513

[1] These columns give the pages and key numbers of Chapter I, where the nature of the character is defined.

TABLE II. *London Femora. Means—Indices.*

Page[1]	Characters	Reference Letter[1]	Males				Females			
			Right		Left		Right		Left	
			No.	Mean	No.	Mean	No.	Mean	No.	Mean
7	Platymeric Index ($I_{h/i}$)	(*j*)	236	85·326 ± ·385	247	85·114 ± ·401	179	84·081 ± ·484	193	81·749 ± ·397
9	Pilastric Index ($I_{k/l}$)	(*m*)	237	105·808 ± ·418	250	103·130 ± ·375	185	103·852 ± ·455	195	99·475 ± ·455
13	Popliteal Index ($I_{p/o}$)	(*r*)	225	70·691 ± ·284	236	70·989 ± ·281	181	67·061 ± ·284	184	68·756 ± ·285
38	Index of Popliteal Skewness ($I_{p/q}$)	(*ll*)	228	90·915 ± ·162	235	91·012 ± ·168	179	90·243 ± ·192	184	90·896 ± ·197
37	Popliteal Pyramidal Index ($I_{o/n}$)	(*cc*)	225	33·414 ± ·214	237	32·699 ± ·189	178	32·787 ± ·226	183	32·876 ± ·243
36	Soffit, or Popliteal Bicondylar, Index ($I_{o/s}$) ...	(*bb*)	150	49·883 ± ·229	163	50·079 ± ·231	99	50·849 ± ·277	111	50·861 ± ·262
38	Index of Gracility (Upper) ($I_{l/i}$)	(*hh*)	236	88·797 ± ·243	247	88·871 ± ·229	179	88·456 ± ·292	193	88·735 ± ·260
38	Index of Gracility (Lower) ($I_{l/o}$)	(*ii*)	230	70·741 ± ·290	239	71·335 ± ·280	180	69·739 ± ·307	184	71·743 ± ·337
38	Index of Transverse Slenderness ($I_{l/u}$)	(*jj*)	226	7·431 ± ·029	228	7·432 ± ·028	167	7·250 ± ·035	180	7·302 ± ·034
38	Index of Sagittal Slenderness ($I_{k/u}$)	(*kk*)	226	7·828 ± ·029	228	7·601 ± ·027	167	7·508 ± ·033	180	7·215 ± ·028
37	Ellipticity of Head ($I_{g/f}$)	(*dd*)	176	98·813 ± ·092	190	98·897 ± ·094	130	99·227 ± ·101	149	98·992 ± ·083
37	Head-Bust Ratio ($I_{f/t}$)	(*ee*)	197	61·450 ± ·266	204	61·190 ± ·257	146	60·512 ± ·312	160	60·875 ± ·297
37	Ellipticity of Neck (I_{n_h/n_v})	(*EE*)	224	76·411 ± ·267	235	75·002 ± ·215	164	77·616 ± ·308	186	76·301 ± ·257
37	Secondary Index of Neck ($I_{n_h/g}$)	(*FF*)	178	55·428 ± ·175	192	55·039 ± ·160	130	55·635 ± ·197	150	55·457 ± ·195
38	Condylar Index ($I_{\sigma_1/s}$)	(*vv*)	138	78·262 ± ·157	141	77·897 ± ·155	88	80·177 ± ·252	100	79·680 ± ·205
39	Condylar Lengths Index (I_{σ_1/σ_2})	(*xx*)	175	100·813 ± ·194	181	99·889 ± ·173	127	101·123 ± ·242	132	100·480 ± ·242
18	Band Radial Index (I_{β_1/β_2})	(I_β)	160	112·506 ± ·641	177	109·721 ± ·559	112	112·075 ± ·679	115	109·528 ± ·658
38	Primary Bust Ratio ($I_{t/a}$)	(*pp*)	213	17·221 ± ·073	214	17·263 ± ·075	157	16·719 ± ·091	169	16·596 ± ·089
38	Secondary Bust Ratio ($I_{t/c}$)	(*rr*)	199	17·333 ± ·075	206	17·363 ± ·075	147	16·822 ± ·097	158	16·744 ± ·092
37	Bust-Shaft Index ($I_{t/u}$)	(*ff*)	227	20·383 ± ·098	229	20·582 ± ·096	167	19·793 ± ·126	182	19·456 ± ·108
38	Capital Ratio ($I_{f/a}$)	(*oo*)	192	10·506 ± ·026	198	10·476 ± ·027	142	10·063 ± ·030	154	10·007 ± ·030
39	Capito-Bicondylar Index ($I_{f/s}$)	(*ww*)	143	58·805 ± ·127	146	59·227 ± ·133	88	58·228 ± ·174	102	58·215 ± ·144
38	Robusticity of Femur ($I_{(k+l)/d}$)	(*tt*)	203	12·967 ± ·037	214	12·720 ± ·034	160	12·652 ± ·046	165	12·487 ± ·043
38	Robusticity of Head ($I_{(f+g)/d}$)	(*uu*)	161	21·068 ± ·057	174	20·983 ± ·054	115	20·261 ± ·065	131	20·099 ± ·060
39	Popliteal Shaft Index ($I_{n/u}$)	(*yy*)	222	32·027 ± ·187	223	32·526 ± ·186	166	32·251 ± ·223	178	31·737 ± ·218
37	Epiphysial Ratio ($I_{t/s}$)	(*gg*)	149	96·064 ± ·462	157	97·663 ± ·457	96	96·762 ± ·678	105	95·731 ± ·509
36	Bicondylar Ratio ($I_{s/a}$)	(*aa*)	152	17·936 ± ·045	161	17·735 ± ·046	99	17·312 ± ·066	112	17·186 ± ·056
38	Bicondylar Trochanteric Index ($I_{s/b}$)	(*qq*)	135	18·822 ± ·048	148	18·720 ± ·052	93	18·220 ± ·069	104	18·054 ± ·060
38	Condylar Trochanteric Index ($I_{\sigma_1/b}$)	(*ss*)	160	14·740 ± ·034	176	14·599 ± ·032	119	14·553 ± ·046	128	14·420 ± ·046
36	Primary Index of Bowing (I_{A_2/A_1})	(*B*)	234	2·587 ± ·031	242	2·515 ± ·029	172	2·503 ± ·037	189	2·501 ± ·033
39	Secondary Index of Bowing (I_{A_3/A_1})	(*zz*)	240	37·092 ± ·294	242	38·603 ± ·328	170	39·468 ± ·480	190	42·624 ± ·440
38	Oblique-Direct Lengths Index ($I_{d/a}$)	(*mm*)	203	99·319 ± ·020	214	99·393 ± ·019	159	99·234 ± ·025	167	99·274 ± ·023
38	Oblique-Direct Trochanteric Lengths Index ($I_{e/b}$)	(*nn*)	172	99·497 ± ·023	195	99·486 ± ·020	135	99·356 ± ·033	147	99·372 ± ·027

[1] These columns give the pages and key numbers of Chapter I, where the nature of the index is defined.

section at the root of the great trochanter, a third includes the gluteal ridge, while a fourth avoids it. As for the angle of torsion, the methods for determining it are as varied as the recorders, and it is almost impossible to lay any stress on racial differences. The same applies largely to the cervical or collar angle, where method of determination is practically all important[1], and where only too often no precise description is given of the method actually adopted. A long study of the correlation of the parts of the human skeleton has convinced us that it is far more

[1] We feel the less hesitation in emphasising this point because we have had considerable and bitter experience in the matter. We measured the collar angle in 800 femora in Dr Warren's manner (Bibl. 77, p. 157) by determining the coaxial point by appreciation on anterior and posterior surfaces, then taking the mean of these two capito-collar lengths and of the two shaft lengths, reconstructing the triangle *COD* (see our Plate I) and measuring by the protractor the angle *CDO* or the cervical angle. This meant days and days of laborious work. The results were:

Collar Angle, English Femora (Warren's Method).

Male		Female	
R.	L.	R.	L.
120°·25 ± ·27	121°·04 ± ·27	120°·52 ± ·36	120°·36 ± ·31

to be compared with Warren's Naqada results:

Male (R. + L.) 124°·26 ± ·56. Female (R. + L.) 126°·82 ± ·44.

Thus we found no significant, R. or L., ♂ or ♀ differences in the English collar angle. Warren found the female significantly greater than the male, and our English value is significantly and markedly less than the Naqada value. We were, however, greatly discontented with this result. We believed that the appreciation of *D* was largely subject to personal equation and that the measurement of *OD* and *CD* on the surfaces of the bone led to an exaggeration of these lengths and so to a reduction in the value of the collar angle. We accordingly adopted the method of orientating the bone and drawing the needful portions of its projection as indicated on our page 20. This again meant a most laborious remeasurement of 800 bones. The results were:

Collar Angle, English Femora (Projection Method).

Male		Female	
R.	L.	R.	L.
130°·40 ± ·30	131°·47 ± ·29	129°·39 ± ·37	130°·28 ± ·37

It will be seen that the change of method has greatly altered our angles, indeed by an amount quite above the order of racial differences. We now conclude that the capito-collar axis is in all probability more nearly horizontal in the female than in the male and in the right bone than in the left. What shall we say about the relative collar angle in Egyptian and English femora? It is probably *less* in the English, because it was so *when measured in both races in the same way.* But our recorded values in Tables IV and V show it to be greater! How can we therefore lay any great emphasis on racial differences, where the recorders very often do not state with any degree of definiteness how their collar angles have been determined? The case illustrated here is only a single instance out of a number where we have discarded a long and laborious system of measurements in favour of what appeared to us a better procedure although it involved hundreds of new measurements and the recalculation of many constants.

essential for progress that authors should measure the *same* characters in precisely the same manner, than that they should endeavour to reach what they hold to be anatomically more homogeneous characters, or anatomically better defined "points." For this reason we have in our measurements endeavoured to embrace (with one or two exceptions[1]) all those of previous serious investigators, and not until this had been done did we feel warranted in adding a few additional measurements of our own and a variety of new indices. This leads us to our second source of difficulty:

(*b*) *Selection by osteometricians of a few characters only to be measured, and those covering only in part the selection of earlier workers in the same field.*

Racial differences may exist of a marked kind just outside this range of selected characters, and the paucity of characters studied is a grave charge, especially against the earlier English writers in this field. Flower and Garson seem to have believed that the mere statement of the length of the femur would be of some service for racial differentiation[2], and a mere superficial examination of our Tables IV and V indicates how on this ground alone the great bulk of racial inferences from femoralogical studies are at present of the most doubtful nature. Even in the few common characters which may be provided for two races we are certain to find several like the collar angle, the angle of torsion or the platymeric index, where we can only seriously doubt whether resemblance or diversity may not be a random result of personal equation, or of the adoption of non-standardised methods. A grave burden falls upon the anthropologist who desires to use femoralogical studies for interracial investigations owing to the fact that many osteometricians who have really made the requisite measurements have not even troubled to calculate the corresponding indices. They must either be obtained from mean values, or an elaborate system of calculations must be undertaken before any comparative work can be done.

(*c*) *Paucity of the numbers with which many authorities have thought it worth while to deal.*

No criticism is raised here of the usefulness of measuring fully even a single bone, but criticism is made of the futility of dealing with such measurements as if any biometric inferences were permissible from them. Much of the deduction of idle inferences from really insignificant differentia would be *à priori* recognised as futile, if it were considered in the case of every osteometric memoir absolutely essential to provide the probable errors of the means stated. It is perfectly true that personal equation and differential methods of measurement lead to divergences which are often of a far higher order than the probable errors, but the latter in the case of two groups measured by a single individual would warn the investigator

[1] For example: the "upper width" of the femur and the "girth of the pilastric section," which we carefully considered before rejection.

[2] Bibl. 24, 32 and 38.

how idle may be the inferences as to sex or side in the case of small numbers. For example in the long memoir of Lehmann-Nitsche[1] on the Row-Grave long bones of Bavaria, extending to nearly a hundred pages, we find in no case more than *fourteen* femora of one side or one sex measured, and often the means given for three, four or five individuals. In no instance is a probable error provided. Thus for the pilastric index a mean of fourteen cases would have a probable error approaching two units and a difference of five units in the pilastric indices given would not necessarily be of any significance. Yet on such differences conclusions are drawn as to race, sex and side differentiation with entire disregard of the values of the probable errors of the means tabulated. In many such instances the probable errors would have indicated that no conclusions as to sex or racial distinctions could be safely based on such paucity of material.

But comparative femoralogical study does not only meet with the above difficulties. Certain writers' views as to indices seem distinctly peculiar. The index is frequently tabled to the first decimal calculated, whatever the second decimal place may contain, and thus at times very considerable errors may arise in the recorded means. Not infrequently also the means are wrongly calculated on the author's own record of measurements. Thus one authority gives the platymeric index of modern British as 81·8, whereas the actual value on his own numbers appears to be 84·6—a result insignificantly different from our own measurements, although had we taken his own figures we should have been compelled to assert a marked difference in this character. The best of us is bound to make arithmetical errors in a long and elaborate inquiry. But all the same we must confess that a wide study of osteometric publications has left us with the impression that too many investigators overlook the fact that computing demands somewhat more training than is acquired by school arithmetic, and above all a healthy sense of responsibility. We have not been able to verify in full the calculations of previous writers, but our partial investigations lead us to the uncomfortable feeling that not only probable errors of random sampling, that not only personal equation, but even errors of arithmetic may account for the divergences which appear to be of marked racial significance in our Tables IV and V[2].

[1] Bibl. 69.

[2] As an illustration of the point let us consider the case of the platymeric index. Here Hepburn follows Manouvrier closely, but forgets in determining his index to raise if needful the last decimal place kept. This alone would lower his mean value. For example an index of 81·18 would appear tabled as 81·1 and not 81·2. Beyond this, however, his mean seems seriously in error. Parsons apparently drops Manouvrier's instruction to take the point of minimum antero-posterior diameter as basis of the platymeric section, and measures "just below the lower trochanter." His measurements are therefore incomparable. He avoids the gluteal ridge. On the other hand Bumüller appears to have included it, for he writes (Bibl. 81, S. 46): "Doch muss bemerkt werden, dass die Hälfte der stenomeren femora den Index 100 haben, also einen neutralen Grenzwert darstellen oder nur durch hohe crista hypotrochanterica diesen Index erlangt haben." Probably his desire to raise the limit of platymery to 85 must be associated with his inclusion of the gluteal ridge. Koganei takes his platymeric section 3 cm. below the root of small trochanter, and we might indefinitely extend the vagaries of the individual observer in the case of this one character!

In our Tables IV and V we have supplied—always in brackets—certain indices by giving not the mean index but the index formed by the ratio of the means of the characters under discussion. We could not take upon ourselves beyond the heavy task involved in our own index calculations, the additional duty of calculating other investigators' indices even when, which is far from the rule, they have given the necessary data. But we can provide some evidence of the amount of error introduced when we replace the mean index by the index of the means. The full theory for obtaining the mean index from the index of the means has been given by one of us in a paper of 1896[1]. It is there shown that the corrective terms involve the coefficients of variation of the characters whose ratio is taken. But these corrective terms are usually small. A more important source of difference—unless we are dealing with very large numbers—arises from the fact that we include in the mean of each absolute character, individuals for which there is no possibility of measuring the paired character. For example, in our data the popliteal width could be measured in 182 female bones of the right side, the mean popliteal width is therefore based on 182 cases. But owing to damage to the epicondyles the number of bicondylar widths available is much reduced and the index popliteal width/bicondylar width could only be found for 99 right female bones. Thus the index of the means is found from a very different series of bones to the mean index[2].

We, of course, used our index of means only as a general method of verifying our mean indices. But in a few cases where the divergence was greater than what seemed permissible owing to the different bones included in the two methods, we calculated the second order terms from our coefficients of variation[3], and this produced a marked agreement indicating that our arithmetic was not in error, and that the non-identity of bones was not of importance.

We can, we hold, for series of 100 cases and upwards[4], assert on the basis of the results recorded in Table III that the mean index may within the limits of the probable errors of random sampling be replaced by the index of the means, where the former has not been calculated, and that it is legitimate to use this value with due caution for comparison with the true index of the means found for other races. Anyhow the index of the means serves as an effective test of general arithmetical accuracy in a long series of calculations.

[1] *R. S. Proc.* Vol. LX, pp. 489—498.

[2] Another good illustration is the index capito-collar length/bicondylar width; only 105 cases were available for the index in left female bones, but the mean capito-collar length was taken on 182 cases.

[3] Such values are given in brackets in Table III under index of means columns. Of course the fact that in tabling the two characters and their index arbitrary units of grouping are used, also affects to some extent the relation between mean index and index of means.

[4] Of course this conclusion is incorrect when mean indices are based on the means of very small series. Illustrations of this occur in Tables IV and V.

TABLE III. *Comparison of Mean Index and Index of Means.*

Index = 100 ×	Male				Female			
	Right		Left		Right		Left	
	M. I.	I. of M.'s	M. I.	I. of M.'s	M. I.	I. of M.'s	M. I.	I. of M.'s
Bicondylar Width / Maximum Length	17·94	17·94	17·74	17·74	17·31	17·10	17·19	17·12
Popliteal Width / Bicondylar Width	49·88	49·70	50·08	49·71	50·85	51·74	50·86	50·82
Popliteal Width / Popliteal Length	33·41	32·89	32·70	32·26	32·79	32·39	32·88	32·21 (32·85)
Horiz. Diam. of Head / Vertical Diam. of Head	98·81	99·12	98·90	99·16	99·23	99·00	98·99	99·34
Vert. Diam. of Head / Capito-collar Length	61·45	61·09	61·19	60·57 (60·99)	60·51	60·14	60·88	60·49
Capito-collar Length / Length of Shaft	20·38	20·38	20·58	20·52	19·79	19·66	19·46	19·39
Capito-collar Length / Bicondylar Width	96·06	96·12	97·66	97·24	96·76	97·51	95·73	96·44
Pilastric Trans. Diam. / Platymeric Trans. Diam.	88·80	88·46	88·87	88·66	88·46	88·18	88·74	88·44
Pilastric Trans. Diam. / Popliteal Width	70·74	70·35	71·34	70·80	69·74	69·45	71·74	71·43
Pilastric Trans. Diam. / Length of Shaft	7·43	7·41	7·43	7·43	7·25	7·24	7·30	7·30
Pilastric Ant. Post. Diam. / Length of Shaft	7·83	7·81	7·60	7·62	7·51	7·49	7·22	7·24
Popliteal Direct Ant. Post. Diam. / Oblique Ant. Post. Diam.	90·92	90·88	91·01	91·02	90·24	90·55	90·90	90·95
Oblique Length / Max. Length	99·32	99·46	99·39	99·50	99·23	99·10	99·27	99·25
Troch. Oblique Length / Troch. Max. Length	99·50	99·41	99·49	99·50	99·36	98·94	99·37	99·60
Vert. Diam. of Head / Max. Length	10·51	10·53	10·48	10·45	10·06	10·03	10·01	9·99
Capito-collar Length / Max. Length	17·22	17·24	17·26	17·25	16·72	16·67	16·60	16·51
Vert. Diam. of Head / Bicondylar Length	58·81	58·72	59·23	58·90	58·23	58·64	58·22	58·33
Sum of Pilastric Diams. / Oblique Length	12·97	12·95	12·72	12·71	12·65	12·61	12·49	12·47
Sum of Diams. of Head / Oblique Length	21·07	21·07	20·98	20·91	20·26	20·14	20·10	20·05
Capito-collar Length / Oblique Length	17·33	17·34	17·36	17·33	16·82	16·82	16·74	16·63
Bicondylar Width / Trochanteric Length	18·82	18·81	18·72	18·66	18·22	18·00	18·05	17·99
External Condylar Length / Trochanteric Length	14·74	14·74	14·60	14·59	14·55	14·48	14·42	14·37
Horiz. Diam. of Neck / Horiz. Diam. of Head	55·43	56·25	55·04	55·22	55·64	55·90	55·46	55·48
External Condylar Length / Bicondylar Length	78·26	78·34	77·90	78·20	80·18	80·45	79·68	79·88
Horiz. Diam. of Neck / Vert. Diam. of Neck	76·41	76·06	75·00	74·80	77·62	77·47	76·30	76·10
Platymeric Index	85·33	84·70	85·11	84·53	84·08	83·37 (84·04)	81·75	81·37
Pilastric Index	105·81	105·39	103·13	102·59	103·85	103·40	99·48	99·20
Popliteal Index	70·69	70·20	70·99	70·61	67·06	66·89	68·76	68·66
Popliteal Length / Length of Shaft	32·03	32·04	32·53	32·52	32·25	32·19	31·74	31·72
Band-radial Index	112·51	111·58	109·72	108·92	112·08	111·31	109·53	108·59 (109·60)
Primary Index of Bowing	2·59	2·60	2·52	2·53	2·50	2·53	2·50	2·52
Secondary Index of Bowing	37·09	37·03	38·60	38·70	39·47	39·74	42·62	42·69
Condylar Index	100·81	101·09	99·89	100·14	101·12	101·52	100·48	100·49

(ii) *Comparison of our London Femoral Measurements with other British Series.*

Our first consideration will be the comparison of our London femora with the measurements of other British femora, but here, alas! there is very little material available, and what exists is not very suitable for the purpose. We take first Hepburn's forty odd British femora; they are modern and probably chiefly Lowlands Scottish. The only length he has taken is the oblique length, and he includes in his means two or three women and one or two unsexed bones. But his Oblique Length (R. and L.) = 456·8 compared with our ♂ R. 444·4, ♂ L. 445·5, and his Bicondylar Width 83·0 compared with our ♂ R. 80·1, ♂ L. 79·4, show that he is dealing with a bigger boned race than our seventeenth century Londoners. Further his Bicondylar Ratio ($I_{s/a}$), 18·2 against our ♂ R. 17·9, ♂ L. 17·7, suggests that for the distal epiphysis his femur is relatively more massive, although the value from his data of the index of robusticity[1], 12·5, is somewhat less than ours, ♂ R. 12·97, ♂ L. 12·72, as well as his index of robusticity of the head[2], *i.e.* 20·8, as against our ♂ R. 21·07, ♂ L. 20·98. Perhaps it would be best to state that his bone is certainly larger, but if anything is very slightly less robust.

In the platymeric region Hepburn and we have followed closely Manouvrier's instructions, and the accordance of our results is very great:

	Hepburn (R. + L.)	Our ♂ R.	Our ♂ L.
Platymeric A.P. Diameter ...	26·5	26·8	26·6
,, Trans. ,, ...	31·6	31·7	31·5
,, Index	84·6[3]	85·3	85·1

This certainly inspires confidence in Manouvrier's method and indicates that platymery has not changed in modern British bones from its seventeenth century value.

In the pilastric region Hepburn's antero-posterior diameter is very slightly greater than ours and his transverse diameter less:

	Hepburn (R. + L.)	Our ♂ R.	Our ♂ L.
Pilastric A.P. Diameter ...	29·7	29·5	28·7
,, Trans. ,, ...	27·2	28·0	28·0
,, Index	109·4	105·8	103·1

[1] Sum of pilastric diameters/oblique length.

[2] Sum of capital diameters/oblique length. Hepburn measures only a single diameter, which we have here doubled.

[3] We believe erroneously given by Hepburn as 81·8, Bibl. 71, p. 155.

It would thus seem that Hepburn's bones are more gracile in the pilastric region, the higher pilastric index arising from a smaller transverse diameter and not from a very much greater pilaster. This is further confirmed by the Indices of Gracility and the Soffit Index, *i.e.* $I_{l/i}$, $I_{l/o}$ and $I_{o/s}$, which give the results stated in the table below. The shaft has, in fact, become more transversely uniform and less in proportion to the epiphysial dimensions.

Index	Hepburn (R. + L.)	Our ♂ R.	Our ♂ L.
Index of Upper Gracility = Pilastric Trans. Diam./Platymeric Trans. Diam.	86·1	88·8	88·9
Index of Lower Gracility = Pilastric Trans. Diam./Popliteal Width ...	66·3	70·7	71·3
Soffit Index = Popliteal Width/Bicondylar Width	48·5	49 9	50·1

We may note that the relations of head to length and of head to bicondylar width have remained much the same, and there is no evidence that the bicondylar width has developed relatively to the head.

Index	Hepburn (R. + L.)	Our ♂ R.	Our ♂ L.
Capito-Bicondylar Index = Diameter of Head/Bicondylar Width	58·8	58·8	59·2
Capital Ratio = Diameter of Head/Maximum Length	10·4[1]	10·5	10·5
Bicondylar Ratio = Bicondylar Width/Maximum Length ...	18·2[1]	17·9	17·7

In the popliteal region Hepburn takes, as we have taken, the 4 cm. rule. He also measures the popliteal length. He considered the vertical length of the popliteal surface to be from the posterior surface of the external condyle to a point where "the margins of the linea aspera were diverging from each other[2]." We have taken it from the centre of the popliteal border of the *fossa intercondyloidea* to the point at which the margins of the *linea aspera* could not be distinguished from each other. We find that at the upper part of the popliteal area the lips of the *linea aspera* may well be parallel, *i.e.* not diverging from each other, for a considerable distance before it is possible to say that the popliteal area has ceased to be. On both these counts our popliteal length will be substantially greater than Hepburn's. In our case the average popliteal length is very closely *one-third* of the shaft length, and it is thus strikingly accurate to speak of the popliteal area as the distal third of the shaft. Hepburn's average (R. + L.) for the popliteal length is 100·1, while our values are ♂ R. 121·1, ♂ L. 122·4, and accordingly this measurement is not comparable in the two series. Hepburn's popliteal section is generally larger than ours, but his antero-posterior

[1] These are obtained by using Hepburn's oblique length; corrected for maximum length we think they should be 10·3 and 18·0 respectively.

[2] Bibl. 71, p. 123.

diameter is 14 °/₀ while his transverse diameter is only 3 °/₀ larger than ours. Thus it results that his popliteal index (R. + L.) is 78·2 against our ♂ R. 70·7, ♂ L. 71·0, differing very widely from ours. In the same way our indices for skewness of the popliteal section—Manouvrier's *mp/mn*—differ very considerably, *i.e.* Hepburn (R. + L.) 97·4 against our ♂ R. 90·9, ♂ L. 91·0. We cannot believe that these figures denote an essential difference of a very marked nature between the popliteal surfaces of the modern and seventeenth century British. The larger absolute values are such as would arise if Hepburn's popliteal section had been *relatively* lower than ours. In this case the popliteal width would be greater, and notwithstanding the usually increased concavity *mp* is relatively more increased as *p* the midpoint of the popliteal surface at the section is moved further from *m*; indeed, with the actual positions of *m*, *n* and *p* in most bones, *mn* and *mp* tend to become equal as we get relatively lower in the popliteal surface. Thus the divergence between Hepburn and ourselves would be more or less accounted for if his section were *relatively* lower. But this it must be, because we both took Manouvrier's 4 cm. from the highest point of the patellar border, and his bones are sensibly longer than ours. This divergence, it seems to us, will always arise if the 4 cm. section be taken. We believe it would be better to take the popliteal section at *one-tenth* of the diaphysial length. This is what we have done with our foetal and child femora, where it was impossible to preserve the 4 cm. rule. *Practically* the tape is taken from zero at the highest point of the patellar border to the point where the antero-trochanteric line meets the anterior border of the upper surface of the neck, and the popliteal section is marked at the same number of mms. on the tape as the latter point reads cms. We wish we had adopted this method throughout, but without a new measurement of Hepburn's femora also no comparison would still have been feasible. As the few measurements hitherto made on the popliteal section have been at 4 cm., it seemed idle to adopt a new rule until it has some more or less universal acceptance.

Our general conclusions from a comparison of Hepburn's and our data would be that the modern British femur differs from that of the seventeenth-century Londoner in being a larger but at the same time a more gracile bone; the practical equality of the indices: Diameter of Head of Femur/Maximum Length, and Bicondylar Width/Maximum Length indicates that the apparently larger distal and proximal epiphyses in the case of the modern British are only in accord with general increase in the size of the bone. If we could suppose Hepburn's modern British and our Londoners to belong to the same race, then we must assert a sensible evolution which has carried the British femur even in historic times further from the gorilloid type or indeed further from *Homo mousteriensis* (Hauser).

We now turn to a comparison of Parsons' Rothwell material. Here the sexes and sides are separated and the material is far more extensive than Hepburn's. But the attempt at comparison is most disheartening, for in the great bulk of cases Parsons has paid no attention to what measurements his predecessors have taken and, adopting an individual line of his own, has rendered all comparison

impossible. In many cases the measurements he has chosen have been more or less standardised by a long series of French or German investigators. Parsons has either not studied their papers, or else has considered his own methods of measurement so superior that all later investigators would willingly adopt them. It is necessary to remark that it needs the influence of great authority to alter an accepted method of measurement, for it involves the scrapping of immense quantities of earlier work.

To begin with Parsons takes his centre of the head "in the upper and front part of the *fovea capitis*[1]." This is not the usual centre of the head. Hence his collar angle is not comparable with that of other authors. He writes, "I am not quite clear how this angle has been taken by other writers[2]"; but surely it was possible to examine their works. His individual choice of the centre of the head makes his collar angle considerably too small; it may well in reality have the same value as ours. Not only this end but the other end of his capito-collar axis disagrees with ours, and thus no comparison is possible. His torsional angle, for reasons given on our pp. 27—28, is also a non-comparable quantity. His obliquity of shaft is roughly in agreement with ours, but does not show the marked differentiation of side which ours indicates. Turning to the platymeric measurements Parsons has disregarded Manouvrier's rule to find the *minimum* antero-posterior diameter first and measure the transverse diameter where this is found. He takes "the antero-posterior width of the shaft just below the lesser trochanter" and "the transverse width of the shaft at the same place[3]." Parsons' platymeric section is thus often 2 cm. above Manouvrier's section of the minimum antero-posterior diameter, and his platymeric measurements, including the index, are quite incomparable with either Hepburn's or ours. In the pilastric region he has again worked individually. He has measured the minimum transverse diameter of the shaft *wherever found*, and not necessarily the transverse diameter in the same horizontal plane as the pilastric antero-posterior diameter. He states that this "least transverse diameter if usually about the middle of the shaft" may be "as low as the junction of the middle and lower thirds," *i.e.* about the apex of the popliteal surface. Hence the pilastric index found from Parsons' data is really incomparable with either our or other writers' values, and the only homologous result is the absolute size of the pilastric diameter. This with Parsons' rough means is in excess of the values found by Hepburn and by us, but is almost exactly in accord with a proportional increase in our antero-posterior diameter due to increased length of femur as a whole. There is accordingly nothing to be learnt from a comparison of our pilastric data. Parsons has no measurements of the popliteal region and no comparison is thus possible. Instead of the usual "bicondylar width" Parsons takes what he terms in one place[4] the "width of the lower extremity," the "transverse diameter of the lower end of the femur[5]" in a second and the "width of lower articulation[6]" in a third place. He nowhere describes accurately how it is

[1] Bibl. 111, p. 241. [2] Bibl. 111, p. 241. [3] Bibl. 111, p. 239.
[4] Bibl. 111, p. 240. [5] Bibl. 111, p. 256. [6] Bibl. 111, Heading to Tables, p. 244 et seq.

measured, but figures on his p. 9 the callipers placed for taking it, and it would thus appear that he has measured the *projection* on the standard vertical plane of the maximum distance from the internal border of the articular surface of the internal condyle to the external border of the articular surface of the external condyle as seen by an observer facing the standard horizontal plane. It is clear that this is incomparable with the bicondylar width, and, owing to the usual state of the borders of the articular surfaces of the condyles in many ancient bones, incapable in those cases of exact determination. It may quite possibly be a useful dimension to take, but it is incomparable with the bicondylar width of other authors, and is surely not fitly described as the diameter or width of the lower extremity of the femur, unless by "lower extremity" is meant not the distal epiphysis, but the extremity of the condylar articular surface.

As a result of this analysis of Parsons' measurements and our own all we can conclude is that the Rothwell femur is for both sexes larger than that of our seventeenth century Londoner. The proportions as judged by the index oblique length/maximum length are identical. But we cannot tell whether the Rothwell bone is or is not more gracile than the London bone. There is some evidence to show that it is more robust[1]. We have made no comparison with the data from London dissecting rooms provided in a still more recent paper of Parsons, because those data are too few for a real comparative study (27 to 31 ♂, 12 to 14 ♀ measurements), and the bones were moist and possessing the articular cartilage.

How far the platymeric index for these moist bones may be considered comparable we cannot say, but it is noteworthy that Parsons now gives a value for it almost identical for males with those found by Hepburn and ourselves, *i.e.* ♂ R. 85·5 and ♂ L. 85·0.

[1] We might have hoped for something from the diameters of the head, but Parsons tells us that he has measured the greatest diameter of the head "with a sliding scale the two bars of which are kept parallel to the long axis of the neck." He has thus obtained only a projection of the diameter measured and there is no evidence whatever that by keeping the calliper bars parallel to his axis of the neck that he will even approximate to the maximum diameter. We have calculated the index of robusticity of the head and index of the robusticity of the shaft as closely as we can from Parsons' material with the following results:

	Robusticity of Head				Robusticity of Shaft			
	♂ R.	♂ L.	♀ R.	♀ L.	♂ R.	♂ L.	♀ R.	♀ L.
Rothwell (1300—1600?)	21·63	21·49	20·72	20·10	13·25	13·60	13·01	13·16
London (1650—1750) ...	21·07	20·98	20·26	20·10	12·97	12·72	12·65	12·49
Modern British ...	20·84		—	—	12·46		—	—

The above data are probably in order of date of origin, and if we can trust Parsons' measurements as really admitting of fair comparison, we see that the order of date is the order of robusticity.

It did not seem possible to pass by Parsons' measurements merely with the remark that they were incomparable with the measurements of other authors, and we have accordingly entered at length into the reasons why they are incomparable. Unless we are to scrap all the work of the earlier femoralogists, in particular of the French writers, and start afresh with Parsons' characters (in which case they will need far more elaborate definition of method of determination than he has provided) there will be small chance of his hope that his study of the Rothwell femora "will serve as a standard for more modern as well as more ancient ones[1]" being fulfilled. Thus the only conclusions we can reach with regard to any system of measurement of British femora that we have come across are:

(i) That the London femur of the seventeenth century was smaller, less gracile and more robust than the femora described by Hepburn as "modern British."

(ii) That the same femur was smaller and less robust than the medieval femora from Rothwell.

The loss of robusticity may be an evolutionary change, but it is equally likely to be—as the absolute size almost certainly is—due to racial differences between the Lowland Scot, the Midland English and the Stuart Londoner.

(iii) *Comparison of English Femur with that of other Races.*

If we now turn to Tables IV and V seeking the racial relationship of our Londoners of the seventeenth century, we are at once checked by paucity of numbers, paucity of characters measured and paucity of races hitherto investigated. Lehmann-Nitsche's results only suffice to show that the races of the Row-Graves of Central Europe were bigger-boned than our Londoners. But what weight can be laid on the femoral head measured in nine or five cases, or the bicondylar width in six or even one instance? Considering the numbers dealt with the pilastric and platymeric indices, the torsional angle and the obliquity are not divergent. The collar angle presents considerable difficulties, for although its value differs considerably from ours, Lehmann-Nitsche's method is very different. He marks[2] the axes of neck and shaft by two black threads on the anterior face; the thread from the middle of the *linea intercondyloidea anterior* to the tuberculum of the *linea intertrochanterica* represents the shaft axis—this is probably a quite good approximation; the axis of the neck is, however, a thread "durch die Mitte des Collum gelegt und durch Visiren bestimmt." We consider this vague and unsatisfactory and that a line thus drawn might easily give a relatively low collar angle. All we can say of the prehistoric central Europeans is that except for absolute size we have no evidence to show that they differ widely from our medieval Londoners.

Modern French will be found to approach nearest to our English values, while modern Swiss are again very close both in pilastric and platymeric

[1] Bibl. 111, p. 238.

[2] Bibl. 69, S. 287.

measurement, although Schwerz has unfortunately only provided us with a mixture of sexes. It is worth remarking that the neolithic French are relatively close to modern French, the substantial differences being in the low platymeric index and the high degree of torsion. This high degree of torsion is only paralleled by the Naqada Egyptian bones and exceeded by the Maori. There is sufficient evidence to show marked links between modern and early Europeans, while there is marked differentiation between both and such Asiatics as we have data for—Japanese and Aino. This is well evidenced in proportion of bicondylar width to maximum length and in that of pilastric to platymeric transverse diameter. The latter, however, must be cautiously dealt with, as the platymeric index must also be, for Koganei took his platymeric section always at an invariable 3 cm. below the small trochanter.

On the whole we see at present how little advantage can be got from comparative study of the femur for racial purposes until there is standardisation of measurements and more numerous measurements on ampler material[1]. This lesson is what we hope will be emphatically illustrated by our tables.

(iv) *Differences associated with Side.*

The discussion of asymmetry seems to have arisen from Lombroso's theory that asymmetry is especially a characteristic of criminals and that this asymmetry is in favour of greater size on the left side. One of the earliest papers actually attempting to measure this asymmetry is due to Garson[2]. He took seventy skeletons of all ages, both sexes and every race, at the Royal College of Surgeons. He took length of femur + tibia as a measure of length of lower limb and found:

No. ...	38	L. > R.	7	L. = R.	25	L. < R.
% ...	54·3	Mean (L. – R.) = + 4·8 mm.	10·0	L. – R. = 0	35·7	Mean (L. – R.) = – 3·3 mm.

Taking femora only Garson found:

No. ...	41	L. > R.	9	L. = R.	20	L. < R.
% ...	58·6	Mean (L. – R.) = + 3·8 mm.	12·8	L. – R. = 0	28·6	Mean (L. – R.) = – 2·9 mm.

The average excess of L. over R. was 1·4 mm.

An obvious criticism of Garson's work is the absence of any recognition on his part that a mixture of ages, sexes and races may appreciably modify the results. In 1893 Matiegka[3] again took up the problem. He dealt with fifty-three skeletons of

[1] We have not included the bulk of Rodriguez's data in our discussion. It is racially very ample, but he deals with few characters and for most combines the sexes. It will be dealt with later under the individual characters and is within its range the best data yet available.

[2] Bibl. 23.

[3] Bibl. 60.

Table IV. *Means (with probable errors) of English Femoral Characters; Comparison with those of other Races*[a].

Males.

Character and Index letter	English (London) R		English (London) L		British (Modern) Hepburn. R + L[δ1]		Rothwell (Mediæval[ε]). Parsons R			Parsons L	Bajuvars from Row Graves. Lehmann-Nitsche[ζ] R		L		Swabians and Alemanns from Row Graves. Lehmann-Nitsche[ζ2] R		L		Swiss Alemanns. Schwerz η_1 R + L		Modern French, Various sources R + L		Neolithic Man, France R + L		Aino Koganei R + L		Japanese. Koganei R + L		Naqada Egyptians. Warren R, or R + L		Fuegians. Martin R + L		Saladoans, Ancient New Mexico Indians Mathews and Workman R		L	
	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No. η_2	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean
(a) Maximum Length	248	446·77 ± 1·02	225	447·50 ± 1·00			76	450	98	460	14	471·4	12	473·8	11	468·5	13	467·8			c. 60	445	34	442·7	44	408·8	20	408·8	80	459·30	5	440·3 γ_1	21	415·3	20	419·3		
(b) Trochanteric Length	187	426·06 ± 1·02	209	425·55 ± 1·00							8	404·1	8	403·1	6	449·9	8	449·2			—		11	419·3	41	390·4	20	389·1			5	408·7						
(c) Maximum Trochanteric Length	184	435·09 ± 1·03	209	434·11 ± 1·03																	—																	
(d) Oblique Length	202	444·35 ± 1·04	244	445·48 ± 1·02	43	450·8	75	453	102	456	14	467·0	12	469·2	13	464·7	13	463·7	c. 170	462·7	62	441	35	440·2	—	—			80	455·05	5	426·8						
(e) Trochanteric Oblique Length	173	423·55 ± 1·06	194	423·40 ± 1·04							8	418·4	8	450·0	7	437·3	8	434·0			—											7	402·2						
(f) Vertical Diameter of Head	203	47·00 ± ·14	212	46·77 ± ·13	30	47·0	76	49	98	49	9	50·3	9	49·8	5	47·3	5	49·2	—		62	47	33	46·0	—	—												
(g) Horizontal Diameter of Head	180	46·60 ± ·14	196	46·38 ± ·13							9	48·0	9	47·8	5	46·1	5	48·2																				
(h) Platymeric A.P. Diameter	240	26·84 ± ·08	247	26·65 ± ·09	44	26·5	80	$\{27\}^{\epsilon_1}$	105	$\{29\}^{\epsilon_1}$	14	29·4	12	27·9	13	25·5	12	26·5	—	—	—		—		47	$\{23·8\}^{\epsilon_4}$	20	$\{22·7\}^{\epsilon_4}$								
(i) Platymeric Transverse Diameter	240	31·68 ± ·13	247	31·52 ± ·12	44	31·6	80	$\{35\}^{\epsilon_1}$	105	$\{36\}^{\epsilon_1}$	14	33·6	12	34·8	13	32·0	12	32·5	—		—		—		47	$\{32·3\}^{\epsilon_4}$	20	$\{29·7\}^{\epsilon_4}$								
(j) Platymeric Index	240	85·33 ± ·40	247	85·11 ± ·40	44	$84·0\delta_2$	80	$\{77\}^{\epsilon_1}$	105	$\{82\}^{\epsilon_1}$	14	87·5	12	80·2	13	79·7	12	81·5	c. 235	80·5	69	$(85·0)^{\theta_1}$	43	76·3	47	$\{73·7\}^{\epsilon_4}$	20	$\{79·4\}^{\epsilon_4}$			5	66·9						
(k) Pilastric A.P. Diameter	237	29·53 ± ·10	250	28·67 ± ·10	44	29·7	79	$\{31\}^{\epsilon_1}$	105	$\{32\}^{\epsilon_1}$	14	30·7	12	29·7	12	29·0	13	29·8	—		—		—		46	27·8	20	25·0					66	26·7	65	26·3
(l) Pilastric Transverse Diameter	241	28·02 ± ·10	250	27·95 ± ·09	44	27·2	79	$\{29\}^{\epsilon_1}$	105	$\{30\}^{\epsilon_1}$	14	29·3	12	29·5	12	27·2	13	28·2	—		—		—		46	26·6	20	24·6					66	23·3	65	22·9
(m) Pilastric Index	237	105·81 ± ·42	250	103·13 ± ·38	44	109·4	80	$\{106·0\}^{\beta_1\epsilon_1}$	105	$\{106·7\}^{\beta_1\epsilon_1}$	14	104·8	12	100·7	12	106·6	13	105·7	c. 214	106·7	69	$(105·8)^{\theta_1}$	43	109·1	46	104·8	20	101·6			5	103·5	66	114·7	65	116·6
(ma) Popliteal Length	230	121·12 ·75	243	122·35 ·67	44	$\{100·1\}^{\gamma\delta_3}$																																
(o) Popliteal Width	232	30·83 ·18	240	30·48 ·17	44	41·3															—	—																
(p) Popliteal Direct A.P. Diameter	228	27·07 ·11	238	27·87 ·12	44	32·3																																
(q) Popliteal Oblique A.P. Diameter	243	30·77 ·11	255	30·92 ·11	44	33·1																																
(mc) Popliteal Index	225	70·60 ·28	240	70·40 ·28	44	78·2																																
(n) Bicondylar Width	153	80·15 ·22	166	79·40 ·22	36	83·0	68	$\{75\}^{\gamma\epsilon_2}$	92	$\{77\}^{\gamma\epsilon_2}$	4	81·6	6	80·1	5	78·3	1 (!)	82·5	c. 88	83·4			—	—	36	78·6	20	79·4			5	75·0						
(t) Capito-collar Length	227	7·04 ·12	229	7·21 ·11			78	$\{105\}^{\zeta_1}$	102	$\{66\}^{\gamma\epsilon_3}$	—	—	—	—	—	—	—	—			—	—			42	$\{67·0\}^{\epsilon_4}$	20	$\{68·1\}^{\epsilon_4}$								
(u) Length of Shaft	227	377·08 ·93	229	376·20 ·94			—				—		—		—		—				—				—		—		45	$\{389·5\}^{\lambda_1}$						
(v) Capito-trochlear Length	227	432·30 1·00	229	432·14 ± ·97		—		—																														
(w) Collar or Cervical Angle	227	130·40 ·30	229	$131·47 \pm ·20$			79	$\{127·7\}^{\gamma}$	104	$\{126·4\}^{\gamma}$	12	124·0	11	125·6	11	$124·7$	11	$127·1$	c. 103	126·3	69	$(125·8)^{\theta_1}$	53	$126·4$	—	—			45	$121·3$	5	123						
(τ_1) Torsional Angle I(ii)*	139	12 10·0 ·30	210	$14·98 \pm ·41$			69	$\{13·3\}^{\gamma}$	98	$13·2\}^{\gamma}$	5	9°·3	4	11°·2	9	7°·5	5	7°·6	c. 82	12°·1	69	$(14·4)^{\theta_1}$	19	29°·0	—	—			33	$23·7$	5	$18·3$						
(τ_1) I(iii)	190	11 03 ·12	210	$14° 71 \pm ·43$		—	71	9	97	9	5 (? ·)	11°·4	5 (? ·)	9°·1	12	10°·4	13	10°·7	c. 104	9°·4	—		22	10°·2							5	8						
(y) Obliquity of Shaft	218	8 09 ·09	243	11 59 ·08			75	$\{6·5\}^{\beta_1}$	98	$\{7°·0\}^{\beta_1}$	14	$\{7°·8\}^{\beta_2}$	12	$\{8°·0\}^{\beta_3}$	(c. 12)	$\{7°·3\}^{\beta_3}$	13	$\{7°·6\}^{\beta_3}$	—	—	c. 60	$\{7°·1\}^{\theta_2}$	c. 34	$\{6·1\}^{\beta_4}$					80	5·8	5	$\{4·8\}^{\lambda_2}$						
(z) Pseudo-obliquity (a)	204	$15·05\}^{\beta}$	214	$15·05\}^{\beta}$		—																																
(aa) Bicondylar Ratio ($I_{n,w}$)	152	17·74 ·04	164	17·73 ·05	35	$\{18·2\}^{\delta_4}$	68	$\{16·4\}^{\beta_1}$	92	$\{16·7\}^{\beta_1}$	(4?)	$\{17·4\}^{\beta_2}$	(4?)	$\{16·4\}^{\beta_2}$	(c. 5)	$\{16·7\}^{\beta_3}$	(c. 1)	$\{17·6\}^{\beta_3}$	—	—	—	—	—	—	c. 36	$\{19·3\}^{\beta_5}$	20	$\{19·4\}^{\beta_5}$			5	$\{18·4\}^{\beta_6}$						
(bb) Popliteal Bicondylar or Soffit Index ($I_{n,t}$)	150	49·88 ·23	163	50·08 ·23	36	$48·5$	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—										
(cc) Popliteal Pyramidal Index ($I_{o/n}$)	225	33·41 ·21	237	32·70 ·19			—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—										
(dd) Ellipticity of Head ($I_{g/f}$)	176	98·81 ·09	190	98·90 ± ·09		—	—				9	97·3	9	96·0	5	97·5	5	98·0	—	—	—	—	—	—	—	—	—	—										
(ee) Head-Bust Ratio ($I_{f/t}$)	197	61·45 ·27	204	$61·19 \pm ·26$		—	76	$\{75·4\}^{\beta_1\gamma\epsilon_4}$	98	$\{74·2\}^{\beta_1\gamma\epsilon_4}$	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—										
(hh) Index of Gracility (Upper) ($I_{f,}$)	236	88·80 ·24	247	88·87 ± ·23	44	86·1	79	$\{82·0\}^{\beta_1}$	105	$\{83·3\}^{\beta_1}$	14	$\{85·2\}^{\beta_2}$	12	$\{84·8\}^{\beta_2}$	(c. 12)	$\{85·0\}^{\beta_2}$	(c. 12)	$\{86·8\}^{\beta_2}$	—	—	—	—	—	—	40	$\{82·4\}^{\beta_5\delta_1}$	20	$\{82·8\}^{\beta_5\delta_1}$										
(ii) Index of Gracility (Lower) ($I_{t,}$)	230	76·41 ·29	240	76·34 ·28	44	66·3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—										
(jj) Index of Transverse Slenderness ($I_{k/t}$)	226	7·43 ·03	228	$7·43 \pm ·03$	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—										
(kk) Index of Sagittal Slenderness ($I_{k/d}$)	226	7·58 ·03	228	$7·60 \pm ·03$	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—										
(ff) Bust-Shaft Ratio ($I_{t/u}$)	227	20·38 ·10	229	$20·58 \pm ·10$	—																								45	18·4								
(gg) Epiphysal Ratio ($I_{e/}$)	149	96·06 ± ·46	157	$97·06 \pm ·46$		—	68	$\{86·7\}^{\beta_1\gamma\epsilon_4}$	92	$\{85·7\}^{\beta_1\gamma\epsilon_4}$	—	—	—	—	—	—	—	—	—	—	—	—	—	—	c. 40	$\{86·4\}^{\beta_5\epsilon_4}$	20	$\{86·5\}^{\beta_5\epsilon_2}$										
(ll) Index of Popliteal Skewness ($I_{p/}$)	228	90·42 ·16	235	$91·01 \pm ·17$	44	$97·1$	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—										
(mm) Oblique Direct Lengths Index ($I_{d/}$)	203	99·32 ·02	214	$99·39 \pm ·02$		—	75	$\{99·3\}^{\beta_1}$	98	$\{99·3\}^{\beta_1}$	14	$\{99·1\}^{\beta_2}$	12	$\{99·0\}^{\beta_2}$	(c. 12)	$\{99·2\}^{\beta_3}$	13	$\{99·1\}^{\beta_3}$	—	—	c. 69	$\{99·0\}^{\theta_1}$	c. 34	$\{99·44\}^{\beta_4}$	—	—			80	$\{99·27\}^{\kappa_2}$	5	$\{99·7\}^{\beta_6}$						
(nn) Oblique Direct Trochanteric Index ($I_{e/b}$)	172	99·50 ·02	195	$99·49 \pm ·02$	—	—	—	—	—	—	8	$\{97·2\}^{\beta_4}$	8	$\{97·2\}^{\beta_2}$	(c. 6)	$\{97·2\}^{\beta_3}$	8	$\{96·6\}^{\beta_3}$	—	—	—	—	—	—	—	—	—	—	—	—	5	$\{98·17\}^{\beta_6}$						
(oo) Capital Ratio ($I_{f/a}$)	192	10·51 ·03	198	$10·48 \pm ·03$	30	$\{10·1\}^{\beta\delta_1}$	76	$\{10·7\}^{\beta_1}$	98	$\{10·7\}^{\beta_1}$	9	$\{10·7\}^{\beta_2}$	9	$\{10·5\}^{\beta_2}$	(c. 5)	$\{10·1\}^{\beta_3}$	(c. 5)	$\{10·5\}^{\beta_3}$	—	—	c. 60	$\{10·8·0\}^{\theta_2}$	c. 33	$\{10·39\}^{\beta_4}$	—	—										
(pp) Primary Bust Ratio ($I_{f/u}$)	213	1·22 ·07	214	$15·26 \pm ·07$	—	—	c. 68	$\{10·4\}^{\beta_1\epsilon_4}$	c. 92	$\{10·7\}^{\beta_1\epsilon_4}$	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	45	15·9						
(qq) Bicondylar Trochanteric Index ($I_{n/b}$)	145	18·82 ·05	148	$18·72 \pm ·05$							(4?)	$\{17·7\}^{\beta_2}$	[6?]	$\{17·1\}^{\beta_2}$	(c. 5)	$\{17·4\}^{\beta_3}$	1 (!)	$\{18·4\}^{\beta_3}$	—	—	—	—	—	—	c. 40	$\{20·1\}^{\beta_5}$	20	$\{20·6\}^{\beta_5}$			5	$\{18·81\}^{\beta_6}$						
(rr) Bicondylar Capital Ratio ($I_{f/a}$)	143	58·81 ± ·13	146	$59·23 \pm ·14$	35	$58·8$	68	$\{60·3\}^{\beta_1\epsilon_4}$	92	$\{63·0\}^{\beta_1\epsilon_4}$	(4?)	$\{61·6\}^{\beta_2}$	(6?)	$\{62·2\}^{\beta_2}$	5	$\{60·4\}^{\beta_3}$	1 (!)	$\{59·6\}^{\beta_3}$	—	—	—	—	—	—	—	—	—	—	—	—								
Midgirth	—	—	—	—	—	—	—	—	—	—	14	94·4	12	93·1	12	87·0	13	88·9	c. 242	92·9	62	88	40	88·7	—	—												

[a] Roughly differences of characters when measured in the same manner may be taken as probably significant when they are $2\sqrt{2}$ to $3\sqrt{2}$, say 3 to 4 times the probable error given in our English columns in magnitude.

* Many writers omit to state how they have dealt with *negative* torsions. (i) disregards sign. (ii) regards it.

β Figures in square brackets are found indirectly, chiefly from ratio of means.

γ Figures in curled brackets are incomparable with ours, being determined by different conventions or processes.

δ_1 All except two are ♂ and probably Lowland Scottish.

δ_2 Hepburn's indices appear to be erroneous and his mean has therefore been corrected.

δ_3 Hepburn gives only oblique, not maximum, length; corrected for this difference these indices should be 18·0 and 10·3.

δ_4 Hepburn measures from limit of external condyle and not from intercondylar fossa: see our p. 9.

ϵ_1 Parsons gives this value as 8 l.

ϵ_2 Parsons has unusual methods of measurement.

β_1 Deduced only from Parsons' means

ϵ_3 Parsons measures the artic ular surface not from epicondyle to epicondyle.

ϵ_4 Not comparable with our length as Parsons measures from capito-collar to spiral line.

ϵ_5 Absolutely incomparable: bicondylar width and capito-collar not ours.

ζ_1 Lehmann-Nitsche's numbers are very inadequate for comparative purposes, and Note *a* needs modification in this sense, the test of significance must be raised, say from 3 to 4 to at least 5 to 6.

β_2 Deduced from Lehmann-Nitsche's means without verification of them.

ζ_2 Numbers very inadequate for comparative purposes: see Note ζ_1.

β_3 See Note β_2.

η_1 Only the characters cited are provided, but others must have been measured to deduce these.

η_2 The numbers of the series are inferential, as exact numbers for each case are not provided.

θ_1 Number of each sex not stated but ♂ + ♀, taken from Rodriguez. Clearly a number of other characters must have been obtained to get these results.

θ_2 From means.

β_4 Deduced from mean values.

ϵ_4 Koganei takes platymeric measurements 3 cm. below small trochanter.

ϵ_2 Koganei takes capito-collar axis from centre of head to trochanter crest.

β_5 Deduced from mean values.

References as under Aino.

κ_1 Found from mean (*ff*) and (*t*) only.

κ_2 This disagrees with 2, so that the 80 bones used in (*o*) and (*d*) can hardly be those used for 2.

λ_1 Martin collecting from all sources gives 25 ♂s, 414 ♀s and 29 ♂s, 390 ♀s.

λ_2 From (*mm*). Found from means only.

Very sparse details of measurements provided for what appears to have been a considerable amount of material.

Character and Index Letter	Symbol	Brightness (Candlepower)	Length (Linear)	Physical Characteristics
(a) Maximum Length	$\mathcal{M}_{a}$	$\mathcal{B}_{a}$	$\mathcal{L}_{a}$	$\mathcal{P}_{a}$
(b) Transverse Length	$\mathcal{M}_{b}$	$\mathcal{B}_{b}$	$\mathcal{L}_{b}$	$\mathcal{P}_{b}$
(c) **Maximum Trochanter Length**	$\mathcal{M}_{c}$	$\mathcal{B}_{c}$	$\mathcal{L}_{c}$	$\mathcal{P}_{c}$
(d) Oblique Length	$\mathcal{M}_{d}$	$\mathcal{B}_{d}$	$\mathcal{L}_{d}$	$\mathcal{P}_{d}$
(e) Trochanteric Oblique Length	$\mathcal{M}_{e}$	$\mathcal{B}_{e}$	$\mathcal{L}_{e}$	$\mathcal{P}_{e}$
(f) Normal Femoral Head	$\mathcal{M}_{f}$	$\mathcal{B}_{f}$	$\mathcal{L}_{f}$	$\mathcal{P}_{f}$
(g) Flexured Femoral Head	$\mathcal{M}_{g}$	$\mathcal{B}_{g}$	$\mathcal{L}_{g}$	$\mathcal{P}_{g}$
(h) Platymeric A.P. Diameter	$\mathcal{M}_{h}$	$\mathcal{B}_{h}$	$\mathcal{L}_{h}$	$\mathcal{P}_{h}$
(i) Platymeric Transverse Diameter	$\mathcal{M}_{i}$	$\mathcal{B}_{i}$	$\mathcal{L}_{i}$	$\mathcal{P}_{i}$
(j) Platymeric Index	$\mathcal{M}_{j}$	$\mathcal{B}_{j}$	$\mathcal{L}_{j}$	$\mathcal{P}_{j}$
(k) Pilaster A.P. Diameter	$\mathcal{M}_{k}$	$\mathcal{B}_{k}$	$\mathcal{L}_{k}$	$\mathcal{P}_{k}$
(l) Pilaster Transverse Diameter	$\mathcal{M}_{l}$	$\mathcal{B}_{l}$	$\mathcal{L}_{l}$	$\mathcal{P}_{l}$
(m) Pilastric Index	$\mathcal{M}_{m}$	$\mathcal{B}_{m}$	$\mathcal{L}_{m}$	$\mathcal{P}_{m}$
(n) Femoral Length	$\mathcal{M}_{n}$	$\mathcal{B}_{n}$	$\mathcal{L}_{n}$	$\mathcal{P}_{n}$
(o) Femoral Width	$\mathcal{M}_{o}$	$\mathcal{B}_{o}$	$\mathcal{L}_{o}$	$\mathcal{P}_{o}$
(p) Diploid Index	$\mathcal{M}_{p}$	$\mathcal{B}_{p}$	$\mathcal{L}_{p}$	$\mathcal{P}_{p}$
(q) Platymeric Oblique A.P. Diameter	$\mathcal{M}_{q}$	$\mathcal{B}_{q}$	$\mathcal{L}_{q}$	$\mathcal{P}_{q}$
(r) Platymeric Index	$\mathcal{M}_{r}$	$\mathcal{B}_{r}$	$\mathcal{L}_{r}$	$\mathcal{P}_{r}$
(s) Platymeric Oblique Index	$\mathcal{M}_{s}$	$\mathcal{B}_{s}$	$\mathcal{L}_{s}$	$\mathcal{P}_{s}$
(t) Platymeric Femoral Index	$\mathcal{M}_{t}$	$\mathcal{B}_{t}$	$\mathcal{L}_{t}$	$\mathcal{P}_{t}$
(u) Platymeric Tibial Index	$\mathcal{M}_{u}$	$\mathcal{B}_{u}$	$\mathcal{L}_{u}$	$\mathcal{P}_{u}$
(v) Platymeric Humeral Index	$\mathcal{M}_{v}$	$\mathcal{B}_{v}$	$\mathcal{L}_{v}$	$\mathcal{P}_{v}$
(w) Platymeric Radial Index	$\mathcal{M}_{w}$	$\mathcal{B}_{w}$	$\mathcal{L}_{w}$	$\mathcal{P}_{w}$
(x) Platymeric Ulnar Index	$\mathcal{M}_{x}$	$\mathcal{B}_{x}$	$\mathcal{L}_{x}$	$\mathcal{P}_{x}$
(y) Platymeric Fibular Index	$\mathcal{M}_{y}$	$\mathcal{B}_{y}$	$\mathcal{L}_{y}$	$\mathcal{P}_{y}$
(z) Platymeric Clavicular Index	$\mathcal{M}_{z}$	$\mathcal{B}_{z}$	$\mathcal{L}_{z}$	$\mathcal{P}_{z}$
(aa) Platymeric Scapular Index	$\mathcal{M}_{aa}$	$\mathcal{B}_{aa}$	$\mathcal{L}_{aa}$	$\mathcal{P}_{aa}$
(bb) Platymeric Innominate Index	$\mathcal{M}_{bb}$	$\mathcal{B}_{bb}$	$\mathcal{L}_{bb}$	$\mathcal{P}_{bb}$
(cc) Platymeric Sternal Index	$\mathcal{M}_{cc}$	$\mathcal{B}_{cc}$	$\mathcal{L}_{cc}$	$\mathcal{P}_{cc}$
(dd) Platymeric Costal Index	$\mathcal{M}_{dd}$	$\mathcal{B}_{dd}$	$\mathcal{L}_{dd}$	$\mathcal{P}_{dd}$
(ee) Platymeric Vertebral Index	$\mathcal{M}_{ee}$	$\mathcal{B}_{ee}$	$\mathcal{L}_{ee}$	$\mathcal{P}_{ee}$
(ff) Platymeric Cranial Index	$\mathcal{M}_{ff}$	$\mathcal{B}_{ff}$	$\mathcal{L}_{ff}$	$\mathcal{P}_{ff}$
(gg) Platymeric Facial Index	$\mathcal{M}_{gg}$	$\mathcal{B}_{gg}$	$\mathcal{L}_{gg}$	$\mathcal{P}_{gg}$
(hh) Platymeric Nasal Index	$\mathcal{M}_{hh}$	$\mathcal{B}_{hh}$	$\mathcal{L}_{hh}$	$\mathcal{P}_{hh}$
(ii) Platymeric Orbital Index	$\mathcal{M}_{ii}$	$\mathcal{B}_{ii}$	$\mathcal{L}_{ii}$	$\mathcal{P}_{ii}$
(jj) Platymeric Palatal Index	$\mathcal{M}_{jj}$	$\mathcal{B}_{jj}$	$\mathcal{L}_{jj}$	$\mathcal{P}_{jj}$
(kk) Platymeric Dental Index	$\mathcal{M}_{kk}$	$\mathcal{B}_{kk}$	$\mathcal{L}_{kk}$	$\mathcal{P}_{kk}$

* Many writers omit to state how they have dealt with wormed bones; we should be glad to be informed in the case of any bone as to whether it is previously separated or not when they are 2 to 3, say 3 to 4 years old, probable error given in our Eighth Memoir, § 8, page 6.

(ii) regards it.

§ Pilastric index is not given because pilasters are found in the femur only in a few cases and then rarely distinctly, though traces of same.

† Figures in cubical brackets are in reference to cubical capacity determined by different conventions or processes.

‡ All except two are ♂ and probably Lombard Street.

§ Elephant's indices appear to be excessive and his mean has therefore been omitted.

TABLE V. *Means (with probable errors) of English Femoral Characters; Comparison with those of other Races*[α].

Female.

Character and Index Letter	English (London) *R* No	English (London) *R* Mean	English (London) *L* No	English (London) *L* Mean	Rothwell (Mediaeval?). *R* No	Rothwell (Mediaeval?). *R* Mean	Parsons *L* No	Parsons *L* Mean	Bajuvars from Row-graves. Lehmann-Nitsche[ζ1] *R* No	Bajuvars from Row-graves. Lehmann-Nitsche[ζ1] *R* Mean	Bajuvars from Row-graves. Lehmann-Nitsche[ζ1] *L* No	Bajuvars from Row-graves. Lehmann-Nitsche[ζ1] *L* Mean	Swabians and Alemanns from Row-graves. Lehmann-Nitsche[ζ2] *R* No	Swabians and Alemanns from Row-graves. Lehmann-Nitsche[ζ2] *R* Mean	Swabians and Alemanns from Row-graves. Lehmann-Nitsche[ζ2] *L* No	Swabians and Alemanns from Row-graves. Lehmann-Nitsche[ζ2] *L* Mean	Swiss Alemanns. Schwerz *R* + *L*[η1] No	Swiss Alemanns. Schwerz *R* + *L*[η1] Mean	Modern French, various sources *R* + *L* No	Modern French, various sources *R* + *L* Mean	Neolithic Women, France *R* + *L* No	Neolithic Women, France *R* + *L* Mean	Aino. Koganei *R* + *L* No	Aino. Koganei *R* + *L* Mean	Japanese. Koganei *R* + *L* No	Japanese. Koganei *R* + *L* Mean	Naqada Egyptians. Warren *R* or *R* + *L* No	Naqada Egyptians. Warren *R* or *R* + *L* Mean	Male and Female Maori. Mollison *R* + *L*[λ1] No	Male and Female Maori. Mollison *R* + *L*[λ1] Mean	Male and Female Modern Swiss, Schaffhausen. Schwerz *R* + *L* No	Male and Female Modern Swiss, Schaffhausen. Schwerz *R* + *L* Mean	Females or Dwarfs[ν1] Neolithic Swiss. Schwerz *R* + *L* No	Females or Dwarfs[ν1] Neolithic Swiss. Schwerz *R* + *L* Mean
(*a*) Maximum Length	171	410·11 ± 1·04	181	408·26 ± 1·06	53	416	49	422	5	424·0	4	428·0	5	416·1	4	393·9[ζ3]	–	–	53	401·1	10	410	25	382·2	20	379·8	113	426·27	6	404·8	20	451·0[μ1]	4	377
(*b*) Trochanteric Length	134	380·06 ± 1·02	163	388·53 ± 1·03					4	411·5	3	419·3	2	411·5	1	384·5	–	–	–	–	4	379·3	25	395·4	20	357·1			6	388·0			3	158
(*c*) Maximum Trochanteric Length	140	397·59 ± 1·00	158	397·05 ± 1·08	–																										22	440·9	4	369
(*d*) Oblique Length	161	406·43 ± 1·07	169	405·21 ± 1·09	52	415	51	418	5	417·8	1	426·8	6	410·4	5	394·4[ζ3]	c. 170	419·0	38	396	24	407·3	–	–	–	–	113	422·15	6	399·7	21	452·7	4	374
(*e*) Trochanteric Oblique Length	136	385·51 ± 1·12	140	385·89 ± 1·08					4	400·5	3	406·7	2	403·3	2	380·0	–	–	–	–	–	–	–	–	–	–	–	–	6	377·7	23	428·8	4	390
(*f*) Vertical Diameter of Head	151	41·12 ± ·11	168	40·77 ± ·10	55	43	48	42	4	43·3	4	44·8	1 (!)	45·0	3	40·3	–	–	38	41	24	40	–	–	–	–	–	–	4	39·25	22	47·1[μ1]	3	48
(*g*) Horizontal Diameter of Head	153	40·71 ± ·12	156	40·50 ± ·11					4	42·4	4	43·5	1 (!)	43·0	3	39·8	–	–	–	–	–	–	–	–	–	–	–	–	4	39·25	22	46·3[μ1]	4	49
(*h*) Platymeric A.P. Diameter	138	24·82 ± ·09	193	25·34 ± ·08	55	{25}[ε1]	50	{26}[ε1]	5	24·0	4	24·5	6	21·8	5	20·6	–	–	–	–	–	–	26	{21·3}[ε1]	20	{19·0}[ε1]	–	–	8	18·9	30	20·9	4	19·8
(*i*) Platymeric Transverse Diameter	138	28·57 ± ·13	193	28·08 ± ·11	55	{32}[ε1]	50	{33}[ε1]	5	31·3	4	31·5	6	28·7	5	27·3	–	–	–	–	–	–	26	{30·8}[ε1]	20	{25·7}[ε1]	–	–	8	30·4	30	31·5	4	28·0
(*j*) Platymeric Index	179	84·08 ± ·18	193	81·75 ± ·10	55	{78}[ε1]	50	{79}[ε1]	1	76·7	1	78·3	6	76·0	5	75·5	c. 235	78·5	69	(85·3)[θ1]	14	75·7	26	{69·2}[ε1]	20	{73·0}[ε1]	–	–	8	62·3	30	85·9	4	1·1
(*k*) Pilastric A.P. Diameter	185	25·05 ± ·10	196	25·10 ± ·10	55	{28}[ε2]	51	{28}[ε2]	5	28·0	4	26·1	6	24·1	5	24·2	–	–	–	–	–	–	26	24·7	20	21·5	–	–	8	26·0	30	28·4	4	24·3
(*l*) Pilastric Transverse Diameter	185	25·20 ± ·10	196	25·37 ± ·10	55	{26}[ε2]	51	{27}[ε2]	5	26·6	1	26·9	6	22·6	5	23·3	–	–	–	–	–	–	26	24·4	20	21·8	–	–	8	22·6	30	27·3	4	23·3
(*m*) Pilastric Index	185	101·85 ± ·10	195	99·48 ± ·10	55	{107·7}[ε2]	51	{103·7}[ε2]	5	105·3	4	97·0	6	106·6	5	103·9	c. 244	103·4	69	(107·8)[θ1]	14	111·3	26	101·2	20	98·6	–	–	8	114·8	30	104·4	4	97·5
(*n*) Popliteal Length	181	112·80 ± ·75	192	110·20 ± ·77																														
(*o*) Popliteal Width	182	36·28 ± ·17	188	35·51 ± ·16	–																												2	34
(*p*) Popliteal Direct A.P. Diameter	182	24·27 ± ·12	188	24·38 ± ·09	–																												2	24
(*q*) Popliteal Oblique A.P. Diameter	181	29·80 ± ·11	184	29·84 ± ·10	–																												–	–
(*r*) Popliteal Index	181	67·00 ± ·28	184	68·70 ± ·20	–																												4	70·3
(*s*) Bicondylar Width	102	70·12 ± ·24	114	69·89 ± ·22	42	{68}[ε3]	46	{67}[ε3]	–		1 (!)	72	1 (!)	74	1 (!)	72	c. 88	74·0	–	–	–	–	22	71·5	20	71·5	–	–	5	69·8	22	80·9	3	67·7
(*t*) Capito Collar Length	167	68·58 ± ·33	182	67·10 ± ·31	54	{50}[ε1]	49	{55}[ε1]	–		–	–	–	–	–	–	–	–	–	–	–	–	24	{62·0}[ε2]	20	{62·0}[ε2]	61	65·1	5	68·2	–	–	4	59·8
(*u*) Length of Shaft	167	347·88 ± 1·07	182	347·00 ± ·93	–				–		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	61	{304·8}[κ1]	–	–	22	386·9	4	320
(*v*) Capito Trochlear Length	167	394·35 ± 1·11	182	393·68 ± 1·01	–				–		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–						
(*w*) Collar or Cervical Angle	167	129·59 ± ·37	182	130·28 ± ·37	54	{126·7}	51	{125·7}	4	127°·0	3	128°·7	5	125°·0	5	128°·6	c. 103	126°·5	69	(125°·8)[θ1]	8	128°·2	–	–	–	–	88	126·8	5	130°·4	23	132°·3	4	124
(*t*$_1$) Torsional Angle *(I)*	151	14·80 ± ·51	192	17·92 ± ·51	49	{18·7}	50	{16·7}	–	–	1 (!)	10°·0	1 (!)	16°·0	3	16°·2	c. 82	15°·0	69	(14·4)[θ1]	6	27·3	–	–	–	–	80	26·1	4	39°·75	15	12·2	3	12·7
(*t*$_{II}$)	151	14·24 ± ·50	192	17·90 ± ·52																														
(*y*) Obliquity of Shaft	166	9·30 ± 11	178	11·55 ± 10	49	10	49	11	5 (♂ +♀)	11·4	5 (♂ +♀)	9°·1	6	9°·3	5	11°·5	c. 164	10°·0	–	–	9	10°·5	–	–	–	–	–	–	5	9°·2	23	9·7	3	9·7
(*z*) Pseudo-obliquity	150	{−·03}[β]	10	{+·03}[β]	52	{+·0}[β1]	49	{−·0}[β1]	5	{11°·8}[β2]	4	{4°·3}[β2]	c. 5	{0°·5}[β2]	–	–	–	–	c. 40	{9°·2}[β4]	c. 10	{6°·6}[β5]	–	–	–	–	113	7°·2	6	{9·1}[β7]	–	–	4	{1·2}[β9]
(*aa*) Bicondylar Ratio (I_{ss})	99	17·51 ± ·07	112	17·19 ± ·06	c. 42	{16·1}[β1]	c. 40	{15·9}[β1]	–	–	c. 1 (!)	{16·8}[β2]	c. 1 (!)	{17·8}[β2]	c. 1 (!)	{18·3}[β2]	–	–	–	–	–	–	22	{18·7}[β4]	20	{18·8}[β4]	–	–	c. 5	{17·2}[β7]	c. 20	{17·0}[β7]	c. 3	{18·0}[β9]
(*bb*) Popliteal Bicondylar or Sofit Index ($I_{s_1s_1}$)	99	50·85 ± ·28	111	50·89 ± ·26	–				–				–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	c. 2	{50·2}[β9]
(*cc*) Popliteal Pyramidal Index (I_{sm})	178	42·09 ± ·23	183	42·88 ± ·21	–				–				–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		
(*dd*) Ellipticity of Head (I_{gf})	130	99·23 ± ·10	139	98·99 ± ·08	–				4	98·0	4	97·1	1 (!)	95·6	3	98·8	–	–	–	–	–	–	–	–	–	–	–	–	1	100	22	{98·3}[β8]	3	100
(*ee*) Head-Bust Ratio (I_{cf})	146	60·51 ± ·31	160	60·88 ± ·30	c. 54	{76·8}[ε3]	c. 48	{73·7}[ε3]	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	c. 4	{57·0}[β7]	–	–	c. 3	{63·5}[β9]
(*hh*) Index of Gracility (Upper) (I_{fi})	170	88·40 ± ·26	193	88·34 ± ·26	55	{81·3}[β1]	50	{81·8}[β1]	5	{85·0}[β2]	4	{85·9}[β2]	6	{78·7}[β3]	5	{85·3}[β3]	–	–	–	–	–	–	26	{79·2}[β6]	20	{84·8}[β6]	–	–	8	{74·3}	30	{80·7}[β8]	4	{83·2}[β9]
(*ii*) Index of Gracility (Lower) (I_{ti})	180	69·71 ± ·31	184	71·74 ± ·34	–				–		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	c. 2	{68·5}[β9]
(*jj*) Index of Transverse Slenderness (I_{ts})	167	7·25 ± ·04	180	7·30 ± ·05	–				–		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4	{7·4}[β9]
(*kk*) Index of Sagittal Slenderness (I_{ss})	167	7·51 ± ·03	180	7·22 ± ·03	–				–		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4	{7·0}[β9]
(*ff*) Bust-Shaft Ratio (I_{ts})	167	19·79 ± ·13	182	19·40 ± ·11	–				–		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	87	17·9	–	–	–	–	4	{18·7}[β9]
(*gg*) Epiphysial Ratio (I_{fg})	96	90·76 ± ·68	105	95·73 ± ·51	c. 42	{82·3}[ε3]	c. 40	{85·1}[ε3]	–	–	–	–	–	–	–	–	–	–	–	–	–	–	c. 22	{86·7}[β6]	20	{86·7}[β6]	–	–	5	{97·7}[β7]	–	–	c. 3	{88·3}[β9]
(*ll*) Index of Popliteal Skewness (I_{p_1})	179	90·23 ± ·19	184	90·00 ± ·20	–				–		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		
(*mm*) Oblique Direct Length Index (I_{dd})	159	99·21 ± ·03	167	99·27 ± ·02	52	{99·8}[β1]	49	{99·1}[β1]	5	{97·0}[β2]	4	{99·7}[β2]	c. 5	{98·0}[β2]	c. 4	{101·4}[β2β3][ζ4]	–	–	c. 40	{98·7}[β4]	c. 10	{99·34}[β5]	–	–	–	–	113	{99·03}[κ2]	6	{98·7}[β7]	c. 20	{100·4}[μ2β7]	4	{99·2}[β9]
(*nn*) Oblique Direct Trochanteric Index (I_{ds})	135	99·30 ± ·03	147	99·37 ± ·03	–				c. 4	{97·3}[β2]	c. 3	{97·0}[β2]	2	{98·0}[β2]	c. 1 (!)	{98·8}[β2]	–	–	–	–	–	–	–	–	–	–	–	–	6	{97·3}[β7]	c. 20	{100·0}[μ2β7]	c. 3	{100·0}[μ2β9]
(*oo*) Capital Ratio (I_{fg})	142	10·06 ± ·04	151	10·01 ± ·04	53	{10·3}[β1]	48	{10·0}[β1]	c. 4	{10·2}[β2]	4	{10·5}[β2]	1 !	{10·8}[β2]	c. 3	{10·2}[β2]	–	–	c. 40	{10·2}[β4]	c. 10	{9·75}[β6]	–	–	–	–	–	–	c. 4	{9·76}[β7]	c. 20	{10·4}[β8]	3	{10·1}[β9]
(*pp*) Primary Bust Ratio (I_{ts})	157	16·72 ± ·09	169	16·60 ± ·09	c. 53	{13·5}[ε3]	49	{13·5}[ε3]	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	87	15·4	c. 5	{10·8}[β7]	–	–	4	{15·1}[β9]
(*qq*) Bicondylar Trochanteric Index (I_{sb})	93	18·22 ± ·07	104	18·05 ± ·06	–	–	–	–	1 (!)	{17·2}[β2]	1 (!)	{18·0}[β2]	1 (!)	{18·7}[β3]	–	–	–	–	–	–	–	–	–	–	–	–	–	–	c. 5	{18·0}[β7]	22	{18·3}[β8]	3	{18·1}[β9]
(*ww*) Bicondylar Capital Ratio (I_{fs})	88	58·23 ± ·17	102	58·22 ± ·14	c. 42	{63·2}[ε3][β1]	c. 40	{62·7}[ε3][β1]	–	–	1 (!)	{62·2}[β2]	1 (!)	{60·8}[β3]	1 (!)	{56·0}[β3]	–	–	–	–	–	–	–	–	–	–	–	–	c. 4	{56·2}[β7]	22	{58·2}[β8]	c. 3	{56·1}[β9]
Midgirth	–	–	–	–	–	–	–	–	5	84·7	4	84·3	6	72·7	5	73·8	c. 242	80·2	38	79	24	80·1	–	–	–	–	–	–	8	74·1	30	80·4	4	71·8

α Roughly differences of characters when measured in the same manner may be taken as probably significant when they are $2\sqrt{2}$ to $3\sqrt{2}$, say 3 to 4 times, the probable error given in our English columns in magnitude.

* Many writers omit to state how they deal with negative torsions; (i) disregards sign, (ii) regards it.

β Figures in square brackets are found indirectly, chiefly from ratio of means.

γ Figures in curled brackets are incomparable being determined by different conventions or processes to ours.

ε_1 Parsons takes his platymeric section just below lesser trochanter.

ε_2 Parsons takes his pilastric transverse wherever that diameter is least.

ε_3 Breadth of articular surface.

ε_4 From top of fovea to spiral line, thus not comparable with our values.

ε_5 Quite incomparable as Parsons' (*s*) and (*t*) are not the same as ours.

β_1 Deduced from Parsons' rough means.

ζ_1 Lehmann-Nitsche's numbers are very inadequate for comparative purposes and Note α requires modification in this sense, say from 3 to 4 to at least 9 to 10 times.

β_2 Deduced from Lehmann-Nitsche's means without verification of them.

ζ_2 Numbers very inadequate for comparative purposes: see Note ζ_1.

β_3: see Note β_2.

ζ_3 This is a good illustration of the danger of working from means of small numbers; (*d*) is greater than (*a*) and the author does not give individual values.

η_1 Only characters cited are given, but others must have been measured to obtain these. The numbers are inferential as exact numbers for each case are not furnished.

θ_1 These are taken from Rodriguez and are for $\zeta + \gamma$; a number of other characters must have been measured by him, but are not given.

β_4 From mean values.

β_5 Deduced from mean values.

ι_1 Koganei takes platymeric section 3 cm. below small trochanter.

ι_2 He takes capito-collar axis from centre of head to trochanteric crest.

β_6 Deduced from mean values.

References as under Aino.

κ_1 Found from mean (*ff*) and (*t*) only.

κ_2 This does not agree very closely with the value given for (*z*).

λ_1 More extensive data for some Maori characters are given by Scott and are dealt with elsewhere in our text

μ_1 Schwerz has clearly errors in his mean $R + L$ for these cases, but the data he gives do not suffice for us to be sure they are now properly corrected.

μ_2 Probably due to errors referred to in μ_1.

ν_1 We have omitted the two large ♂ skeletons.

ν_2 Due to paucity of numbers.

$\beta_7 = \beta_8 = \beta_9 = \beta$.

TABLE V. Means

Character and Index Letter	English (London) L		English (London) R		Scotland (Aberdeen) R		Parsons L	
	No.	Mean	No.	Mean	No.	Mean	No.	Mean
(a) Maximum Length	181	180·11 ± 0·64	181	179·65 ± 0·62	74	179	19	182
(b) Projective Length	181	130·60 ± 0·52	183	130·23 ± 0·51				
(c) Maximum Trechmannic Length	180	80·33 ± 0·30	182	80·05 ± 0·29				
(d) Oblique Length	181	100·13 ± 0·52	180	100·21 ± 0·50	54	101	21	102
(e) Trechmannic Oblique Length	179	38·31 ± 1·12	149	38·26 ± 1·08				
(f) Vertical Diameter of Head	181	41·12 ± 0·11	168	40·17 ± 0·10	55	43	18	44
(g) Horizontal Diameter of Head	182	40·13 ± 0·12	180	40·20 ± 0·11				
(h) Platymeric A.P. Diameter	178	27·82 ± 0·09	167	27·85 ± 0·08	55	28	20	28
(i) Platymeric Transverse Diameter	178	20·71 ± 0·1	167	20·68 ± 0·1	55	21	20	21
(j) Platymeric Index	178	74·50 ± 0·4	167	74·15 ± 0·4	55	75	20	76
(k) Platastic A.P. Diameter	182	20·05 ± 0·10	166	20·10 ± 0·10	55	20	21	20
(l) Platastic Transverse Diameter	182	25·20 ± 0·10	166	25·35 ± 0·10	55	26	21	25
(m) Platastic Index	182	10·78 ± 0·10	166	10·84 ± 0·10	55	10	21	10
(n) Popliteal Length	181	113·00 ± 0·75	102	110·20 ± 0·70				
(o) Popliteal N Width	182	30·28 ± 0·1	182	32·21 ± 0·10				
(p) Popliteal Dir. A.P. Diameter	182	24·25 ± 0·12	182	24·38 ± 0·09				
(q) Popliteal Oblique A.P. Diameter	181	20·80 ± 0·11	181	21·81 ± 0·10				
(r) Popliteal Index	181	0·700 ± 0·28	181	0·681 ± 0·26				
(s) Bicondylar N Width	182	0·12 ± 0·1	111	00·80 ± 0·1	42	00·1	19	00·1
(t) Sciatic Collar Length	182	00·12 ± 0·1	182	0·10 ± 0·1	31	00·1	18	00·1
(u) Length of Shaft	107	34·88 ± 0·09	182	34·00 ± 0·08				
(v) Sciatic Trochlear Length	107	30·13 ± 0·11	182	30·05 ± 0·09				
(w) Collar or Cervical Angle	107	120·00 ± 0·4	182	120·24 ± 0·3	41	120	21	120
(ι_1) Femoral Angle ($\iota(1)^*$	182	11·00 ± 0·1	102	11·00 ± 0·1	21	10	20	10
(x) Obliquity or Shaft	182	0·30 ± 0·11	102	0·30 ± 0·10	21	00	20	00
(y) Pseudo-obliquity	180	0·30 ± 0·11	102	[illegible]	21	00	20	00
(zz) Bicondylar Ratio (ι_{zz})	90	12·21 ± 0·7	182	12·10 ± 0·06	41	12	19	12
(aa) Popliteal Bicondylar or Shaft Index (ι_{zz})	90	30·52 ± 0·28	111	30·20 ± 0·26				
(bb) Popliteal Bicondylar Index (ι_{zz})	172	42·50 ± 0·3	182	42·08 ± 0·3				
(cc) Ellipticity of Head (ι_{yy})	130	00·5 ± 0·1	180	00·50 ± 0·05				
(dd) Head Bust Ratio (ι_{yy})	130	00·51 ± 0·1	180	00·55 ± 0·1				
(ee) Index of Gracility (Upper) (ι_{yy})	120	50·10 ± 0·20	101	50·10 ± 0·20				
(ff) Index of Gracility (Lower) (ι_{yy})	120	60·10 ± 0·21	181	60·11 ± 0·21				
(gg) Index of Transverse Slenderness (ι_{zz})	107	7·25 ± 0·1	180	7·30 ± 0·1				
(hh) Index of Sagittal Slenderness (ι_{zz})	107	7·21 ± 0·1	180	7·22 ± 0·1				
(ii) Bust Shaft Ratio (ι_{yy})	107	10·30 ± 0·1	182	10·10 ± 0·1				
(jj) Epiphyseo-Bust Ratio (ι_{yy})	90	00·00 ± 0·0	102	00·53 ± 0·1				
(kk) Index of Proximal Slenderness (ι_{zz})	120	00·24 ± 0·0	182	00·00 ± 0·0				
(ll) Oblique Distal Length Index (ι_{yy})	120	00·1 ± 0·0	181	00·2 ± 0·0				
(mm) Oblique Distal Trochanteric Ind. (ι_{yy})	120	00·30 ± 0·0	181	00·2 ± 0·0				
(nn) Capital Radius (ι_{yy})	112	10·00 ± 0·0	181	10·01 ± 0·0				
(oo) Primary Bust Ratio (ι_{yy})	112	10·00 ± 0·0	180	10·00 ± 0·0				
(pp) Bicondylar Trochanteric Index (ι_{yy})	91	18·22 ± 0·0	101	17·00 ± 0·00				
(qq) Platymeric Index (ι_{yy})	178	74·50 ± 0·4	167	74·15 ± 0·4	55	75	20	76
(rr) Platastic Index (ι_{yy})	182	10·78 ± 0·10	166	10·84 ± 0·10	55	10	21	10
(ss) Popliteal Index (ι_{yy})	181	0·700 ± 0·28	181	0·681 ± 0·26				
(tt) Bicondylar Ratio (ι_{yy})	90	12·21 ± 0·7	182	12·10 ± 0·06	41	12	19	12
(uu) Ellipticity of Head (ι_{yy})	130	00·51 ± 0·1	180	00·55 ± 0·1				
(vv) Index of Transverse Slenderness (ι_{zz})	107	7·25 ± 0·1	180	7·30 ± 0·1				
(ww) Index of Sagittal Slenderness (ι_{zz})	107	7·21 ± 0·1	180	7·22 ± 0·1				

* Many writers omit to state how they deal with negative torsions: (i) disregard signs, (ii) regards it.

† Bimodality detected in sex-mixed series.

‡ Figures in square brackets are found indirectly, chiefly from data of previous writers.

§ Figures in round brackets are means of pseudo-being determined by different conventions or processes to ours.

¶ Data incomparable as Parsons and (i) are not the same as ours.

** Deformed from Paget, rough mean.

†† Parsons table to platymeric index just below lesser trochanter.

‡‡ Mean value platastic index [illegible] Broadth of platastic surface.

§§ Parsons report to a special line, this not comparable with our value.

adult and growing individuals in the Prag Anatomical Institute. He distinguishes sex and age, as far as adult and non-adult are concerned, and he considers all six long bones. He does not consider race and he does not give the actual measurements, but only the percentages of equality, of excess and of defect in R. and L. He considers only the maximum lengths of the bones. His conclusions are that in both male and female the lower limb is in excess on the left and the upper limb is in excess on the right. In the non-adult group (12—21 years), the distinction appears to be less marked and the number of cases of equality considerably larger.

If we pick out his results for the femur, which more especially concerns us at present, we have the table given below. It will be seen that his numbers are very slender and without measurements very difficult of exact interpretation. Clearly Matiegka's percentages are in themselves quite unreliable[1].

Maximum Length of Femur

	No.	L. = R.	L. > R.	L. < R.
Male Adult	13	2	11	0
Female Adult	12	5	3	4
Males, 12—21 years ...	24	7	12	5
Females, 9—19 years ...	4	2	1	1
Totals	53	16	27	10

As far, therefore, as the femur is concerned these results show nothing for adult or non-adult females, but they do indicate some considerable emphasis of the left side in the case of males. Unfortunately in bones from plague pits the pairing is impossible and we can only trust to large numbers reducing to small proportions our mean value differences for right and left bones. Warren in 1898[2] used both the percentage method and the mean method, but as he was able to pair the bones in 114 cases he took only paired bones. His results give for

Oblique Length

		No.	Right	No.	Left	$\Delta_{R.-L.}$
Naqada	♂ ...	48	453·25 ± 2·45	48	454·20 ± 2·39	−1·25 ± 3·42
	♀ ...	66	421·41 ± 1·61	66	422·86 ± 1·71	−1·45 ± 2·35
London	♂ ...	202	444·35 ± 1·03	214	445·48 ± 1·02	−1·13 ± 1·45
	♀ ...	161	406·43 ± 1·07	169	405·21 ± 1·09	+1·16 ± 1·58
Rothwell	♂ ...	76	453 ± (?1·68)	98	456 ± (?1·51)	−3·0 ± (?2·21)
	♀ ...	52	415 ± (?1·88)	51	418 ± (?1·96)	−3·0 ± (?2·72)

[1] Matiegka apparently had the epiphyses present, if wholly or partially loose on his young bones. These are usually absent in the bulk of disinterred young bones.

[2] Bibl. 77, pp. 140, 146.

Parsons takes his means to the nearest millimetre only and gives no probable errors. He states that in both sexes the left member exceeds the right by 3 mm., and that he finds the same 3 mm. on the femora of *sixteen* bodies from the dissecting rooms of St Thomas's and Guy's Hospitals[1]. This result is not in accord with Garson's − 1·4, or Warren's or our numbers of the same order. We have attached probable errors to Parsons' results on the hypothesis that the variation of the Rothwell femora may be taken as approximately equal to that of the London femora. It will be seen that to the nearest millimetre he has a probable error of above two in his means, or his difference of three has no significance. The same applies to Warren's and our individual results. It would require far larger numbers than any of us have used to test by this method whether the left exceeds the right femur by 1 to 2 mm. There is no doubt that the same criticism applies to Garson's conclusions and Matiegka's numbers for the femur alone are absolutely inadequate. Although there is some evidence arising from five out of the six series in the last table running the *same* way, it will require something like 1000 pairs of femora to determine whether there is a real excess of say 1 mm. in length in the left bone[2]. In our own series, the longest hitherto dealt with, males go one way and females the other and in neither case is the difference significant. We conclude that asymmetry in length of femur, while the rule rather than the exception has not yet been *demonstrated* to give a predominance to the left bone.

We shall now proceed to a more systematic investigation of the possible influence of side. This will consist of determining the difference between right and left members in terms of the probable error of that difference for each character. A difference between right and left cannot be considered possibly significant if it is less than twice its probable error, and not until it is three or four times can we assert highly probable significance. Doubtful cases we can only consider, if they are confirmed both as to magnitude and sign by the other sex. In the accompanying table we give first the character, then its value in the right minus its value in the left limb, $\Delta_{R.-L.}$, together with the probable error of the difference e_Δ. In the last column is given the ratio, $\Delta_{R.-L.}/e_\Delta$. The results are surprising and somewhat illuminating with regard to the manner in which conclusions are frequently drawn from inadequate data by defective theory. The differences in right and left members of none of the chief lengths, maximum and oblique or trochanteric maximum and oblique, appear to have any significance[3]. This is also true of various subsidiary lengths such as the popliteal length, length of shaft, the capito-trochlear length, the capito-collar axis, the vertical band radius of the external

[1] Bibl. 111, pp. 242—3.

[2] Nearly one centimetre (0·8) of Parsons' R. and L. difference is due to the presence of a single subgiant L. femur (Max. Length: 543), which has clearly no paired R. femur in his data. This is a good illustration of the difficulty of dealing with non-paired bones in relatively small numbers.

[3] Not only are the values of the right and left differences insignificant but they differ in sign in the two sexes.

TABLE VI. *Differences of Absolute Measurements on Right and Left Sides for Male and Female Femora.*

Nature of Difference	Male			Female		
	Character	$\Delta_{R.-L.} \pm e_\Delta$	$\frac{\Delta_{R.-L.}}{e_\Delta}$	Character	$\Delta_{R.-L.} \pm e_\Delta$	$\frac{\Delta_{R.-L.}}{e_\Delta}$
Very Significant	Obliquity	− 2°·906 ± ·125	− 23·2	Obliquity	− 2°·379 ± ·147	− 16·2
	Torsion of Shaft	− 4°·973 ± ·795	− 6·3	Torsion of Shaft	− 6°·711 ± ·922	− 7·3
	Pilastric A. P. Diam.	+ 0 ·860 ± ·144	+ 6·0	Pilastric A. P. Diam.	+ 0 ·888 ± ·144	+ 6·2
	Torsion of Femur	− 3°·079 ± ·600	− 5·1	Torsion of Femur...	− 3° 653 ± ·759	− 4·8
	Ditto (disregarding sign) ...	− 2°·876 ± ·562	− 5·1	Ditto (disregarding sign) ...	− 3°·056 ± ·723	− 4·2
	Retorsion	− 2°·994 ± ·668	− 4·5	Platymeric A. P. Diam.	+ 0 ·481 ± ·119	+ 4·0
Probably Significant	Oblique Length, External Condyle	+ 0 ·798 ± ·204	+ 3·9	Popliteal Width	+ 0 ·793 ± ·233	+ 3·4
	Max. Length, External Condyle...	+ 0 ·696 ± ·215	+ 3·2	Retorsion	− 2°·317 ± ·699	− 3·3
				Oblique Length, External Condyle	+ 0 ·637 ± ·196	+ 3·3
Possibly Significant	Angle, Centre of Head	+ 1°·010 ± ·351	+ 2·9	Max. Length, External Condyle	+ 0 ·585 ± ·213	+ 2·7
	Ext. Cond., Horiz. Band-radius...	− 0 ·368 ± ·137	− 2·7	Vertical Diam. of Head	+ 0 ·358 ± ·154	+ 2·3
	Collar Angle	− 1°·070 ± ·417	− 2·6	Horiz. Diam. of Neck	+ 0 ·292 ± ·125	+ 2·3
	Bicondylar Width	+ 0 ·743 ± ·307	+ 2·4	Ext. Cond., Horiz. Band-radius...	− 0 ·324 ± ·148	− 2·2
	Vert. Diam., Neck	− 0 ·387 ± ·168	− 2 3	Capito-collar Length	+ 0 ·984 ± ·454	+ 2·2
Non-Significant	Diaphysial Subtense	+ 0 ·163 ± ·111	+ 1·5	Mid. Trochlear Angle	+ 0°·181 ± ·097	+ 1·9
	Vert. Diam. of Head	+ 0 ·290 ± ·188	+ 1·5	Diaphysial Chord...	+ 2 ·526 ± 1·299	+ 1·9
	Platymeric A. P. Diam.	+ 0 ·185 ± ·120	+ 1·5	Collar Angle	− 0°·887 ± ·525	− 1·7
	Popliteal Width	+ 0 ·359 ± ·247	+ 1·5	Popliteal Length	+ 1 ·745 ± 1·077	+ 1·6
	Length of Shaft	+ 1 ·777 ± 1·321	+ 1·3	Angle at Centre of Head ...	+ 0°·592 ± ·448	+ 1·3
	Horiz. Diam. of Head	+ 0 ·222 ± ·189	+ 1·2	Pilastric Trans. Diam.	− 0 ·172 ± ·137	− 1·3
	Mid. Trochlear Angle	+ 0°·093 ± ·078	+ 1·2	Horiz. Diam. of Head	+ 0 ·214 ± ·160	+ 1·3
	Popliteal Length	− 1 ·230 ± 1·006	− 1·2	Max. Length	+ 1 ·857 ± 1·479	+ 1·3
	Horiz. Diam. of Neck	+ 0 ·138 ± ·134	+ 1·0	Vertical Diam. of Neck	− 0 ·143 ± ·142	− 1·0
	Popl. Oblique A. P. Diam. ...	+ 0 ·152 ± ·156	+ 1·0			
	Platymeric Trans. Diam. ...	+ 0 ·154 ± ·175	+ 0·9	Popliteal Direct A. P. Diam. ...	− 0 ·114 ± ·150	− 0·8
	Oblique Length	− 1 ·130 ± 1·449	− 0·8	Trochanteric Length	+ 1 ·130 ± 1·451	+ 0·8
	Ext. Cond., Vert. Band-radius ...	+ 0 ·098 ± ·128	+ 0·8	Oblique Length	+ 1 ·215 ± 1·523	+ 0·8
	Max. Troch. Length	+ 0 ·976 ± 1·467	+ 0·7	Bicondylar Width	+ 0 ·237 ± ·315	+ 0·8
	Max. Length	− 0 ·929 ± 1·428	− 0·7	Ext. Condyle, Vert. Band-radius	+ 0 ·102 ± ·139	+ 0·7
	Pilastric Trans. Diam.	+ 0 ·073 ± ·130	+ 0·6	Diaphysial Subtense	+ 0 ·087 ± ·120	+ 0·7
	Popliteal Direct A. P. Diam. ...	+ 0 ·093 ± ·157	+ 0·6	Platymeric Trans. Diam. ...	− 0 ·111 ± ·171	− 0·6
	Max. Length, Internal Condyle...	+ 0 ·106 ± ·232	+ 0·5	Capito-Trochlear Length... ...	+ 0 ·675 ± 1·496	+ 0·5
	Capito-collar Length	− 0 ·175 ± ·442	− 0·4	Max. Trochanteric Length ...	− 0 ·363 ± 1·530	− 0·2
	Trochanteric Length	+ 0 ·511 ± 1·424	+ 0·4	Trochanteric Oblique Length ...	− 0 ·349 ± 1·550	− 0·2
	Capito-Trochlear Length... ...	+ 0 ·255 ± 1·388	+ 0·2	Length of Shaft	+ 0 ·279 ± 1·417	+ 0·2
	Diaphysial Chord...	− 0 ·134 ± 1·192	− 0·1	Max. Length, Internal Condyle...	+ 0 ·013 ± ·224	+ 0·1
	Trochanteric Oblique Length ...	+ 0 ·090 ± 1 482	+ 0·1	Popliteal Oblique A. P. Diam. ...	− 0 ·009 ± ·144	− 0·1

condyle, the vertical diameters of head and neck and the diaphysial chord. We now turn to measurements perpendicular to the sagittal plane or to the standard vertical plane. No stress can be laid on side differences in the bicondylar width, in the pilastric transverse diameter or in the platymeric transverse diameter; on the other hand, the popliteal width difference appears to have some significance in the female, none in the male bones. As all other lengths perpendicular to the sagittal plane have insignificant differences, we must not lay too great stress on this apparently significant but uni-sexual difference in the case of the popliteal width.

The matter stands somewhat differently when we turn to perpendiculars to the standard vertical plane. The maximum length of the internal condyle (really rather markedly oblique to the standard vertical plane), the popliteal direct and oblique antero-posterior diameters, the diaphysial subtense, the horizontal diameters of head and of neck appear to have no differences on right and left side. But the pilastric antero-posterior diameter is markedly differentiated, the platymeric antero-posterior diameter definitely in the female, but not in the male bones, while the external condylar length (oblique or maximum), and quite possibly the horizontal band-radius of the same condyle[1] are differentiated.

Turning now to the angles, we note that none of the angles of the fundamental triangle—the collar angle, angle at the centre of head or the mid-trochlear angle—show uniform and definite side differences, although both sexes agree in making the collar angle less on the right side. On the other hand, the torsion, however measured—as torsion of whole bone or of shaft alone, or as retorsion of head and neck, or whether we pay attention to its sign or not in the first case—is always markedly greater in the left than the right bone. Further the obliquity is most definitely and markedly greater in the left bone than in the right.

To sum up our conclusions with regard to side differences in the femur: if a mechanical action were at work in the case of the right femur causing it to carry more continuously a greater load than the left—for example if the left is more frequently adopted as "Spielbein" and the right as "Ruhebein"—then we should anticipate that some or all of the vertical lengths would be smaller on the right side and possibly some or all the horizontal lengths—due to the longitudinal compression being greater—would be larger. We do not find, however, any of the left side vertical lengths in excess, nor do we find any of the transverse diameters markedly in excess on the right side. Two of the principal—the platymeric and pilastric—antero-posterior diameters and the external condylar length do appear to be significantly in excess on the right side. If we suppose there to be really excess pressure on the right side, then we are compelled to suppose that the bone reacts and grows more under this pressure, and that would account for the greater development of the sagittal diameters. But such a hypothesis does not account for the popliteal section showing no

[1] It should be noticed, however, that while the other antero-posterior characters show excess on the right side, the horizontal band-radius shows defect.

increase of antero-posterior diameter on the right side, nor for the absence of excess on the same side of the transverse lengths. We doubt very much whether the mechanical explanation will coordinate the observed differences in the most significant cases. Now we shall show later that the principal part of the torsion occurs above the pilastric section, and we shall suggest that this torsion strengthens the bone in the principal plane of bending even as the pilaster does. We look therefore on the reduced torsion of the right femur as to some extent compensated for by increased antero-posterior diameters in the proximal half of the bone. It is conceivable that lessened torsion carries as its correlative lessened obliquity, although we are not prepared at present with any explanation on this point. All we would suggest is that the defect of obliquity and torsion and the excess of antero-posterior dimensions in the right femur are, in our view, an associated system and embrace the main differences of size and form between right and left bones. We do not believe these differences to be due to differential mechanical causes, but rather evolved as all differences in homologous parts of the human frame, and ultimately traceable in this case to differences of muscular attachment and arrangement enforced by the organic asymmetry of the human frame.

The reader of this memoir must be careful to note that we do not assert that there is an absence of slight length differences in the right and left femur; it might be possible to determine such, if they exist, with a really adequate number of actually paired bones. All we assert is that we cannot discover such differences in our material, and that previous writers on the subject seem to have wholly overlooked the importance of testing their differences by aid of the probable errors of their observations[1].

We now turn to the possibility of side-differences in the indices of the femur. But the matter is here more complicated; there are marked sex differences in almost two-thirds of our femoral indices, and accordingly we may not find nearly so great an accord between significant right and left differences in the indices of the two sexes.

Here again we notice that none of the indices formed from the main lengths of the femur show any conspicuous right and left differentiation. The Oblique Length/Maximum Length in males is "possibly significant," but although of the same sign in the female bones it is so low down in the "insignificant" that we think no weight can be given to the male value. The index, again, Bicondylar Width/Maximum Length, just gets into the probably significant in males, but is so low in females, that we by no means feel certain that it should be noted as a secondary sexual character, that in the right femur of *males* the distal epiphysis is relative to the size of the bone more developed than in the left.

We have to recognise that it is in the indices of the smaller dimensions of

[1] Our results confirm for the present material Pearson's conclusions (Bibl. 79, p. 197) for the *femur* in 1898, *i.e.* that the differences between R. and L. were insignificant and so vaguely determined that it was best to neglect them. He cited Rollet's values (c. 100 cases) on dissecting room material, ♂, R.–L. = – ·4 mm. and ♀, R.–L. = + ·3 mm., the signs of which at any rate agree with our present experience.

TABLE VII. *Differences of the Indices on Right and Left Sides for Male and Female Femora.*

Nature of Difference	Male			Female		
	Index	$\Delta_{R.-L.} \pm e_\Delta$	$\frac{\Delta_{R.-L.}}{e_\Delta}$	Index	$\Delta_{R.-L.} \pm e_\Delta$	$\frac{\Delta_{R.-L.}}{e_\Delta}$
Very Significant	Pilastric A. P. Diam./Shaft Length ...	$+0{\cdot}227 \pm {\cdot}040$	$+5{\cdot}7$	Pilastric A. P. Diam./Shaft Length ...	$+0{\cdot}293 \pm {\cdot}043$	$+6{\cdot}8$
	Robusticity of Shaft	$+0{\cdot}247 \pm {\cdot}050$	$+4{\cdot}9$	Pilastric Index	$+4{\cdot}377 \pm {\cdot}643$	$+6{\cdot}8$
	Pilastric Index	$+2{\cdot}678 \pm {\cdot}575$	$+4{\cdot}7$	Popliteal Index	$-1{\cdot}987 \pm {\cdot}418$	$-4{\cdot}8$
	Ellipticity of Neck	$+1{\cdot}409 \pm {\cdot}343$	$+4{\cdot}1$	Secondary Index of Bowing	$-3{\cdot}156 \pm {\cdot}651$	$-4{\cdot}8$
				Index of Gracility (Lower)	$-2{\cdot}102 \pm {\cdot}466$	$-4{\cdot}5$
Probably Significant	Ext. and Int. Condylar Lengths ...	$+0{\cdot}924 \pm {\cdot}260$	$+3{\cdot}6$	Platymeric Index	$+2{\cdot}332 \pm {\cdot}626$	$+3{\cdot}7$
	Band-radial Index	$+2{\cdot}785 \pm {\cdot}850$	$+3{\cdot}3$	Ellipticity of Neck	$+1{\cdot}315 \pm {\cdot}401$	$+3{\cdot}3$
	Ext. Condylar Length/Trochanteric Length	$+0{\cdot}141 \pm {\cdot}047$	$+3{\cdot}1$			
	Bicondylar Width/Maximum Length ...	$+0{\cdot}201 \pm {\cdot}064$	$+3{\cdot}1$			
Possibly Significant	Oblique Length/Maximum Length ...	$-0{\cdot}074 \pm {\cdot}028$	$-2{\cdot}6$	Band-radial Index	$+2{\cdot}547 \pm {\cdot}946$	$+2{\cdot}7$
	Popliteal Pyramidal	$+0{\cdot}715 \pm {\cdot}286$	$+2{\cdot}5$	Robusticity of Shaft	$+0{\cdot}165 \pm {\cdot}063$	$+2{\cdot}6$
	Capito-collar Length/Bicondylar Width	$-1{\cdot}599 \pm {\cdot}650$	$-2{\cdot}5$	Popliteal A. P. Diam. direct/oblique ...	$-0{\cdot}653 \pm {\cdot}275$	$-2{\cdot}4$
	Vert. Diam. of Head/Bicondylar Width	$-0{\cdot}422 \pm {\cdot}184$	$-2{\cdot}3$	Ext. Condylar Length/Trochanteric Length	$+0{\cdot}133 \pm {\cdot}065$	$+2{\cdot}0$
				Capito-collar Length/Shaft Length ...	$+0{\cdot}337 \pm {\cdot}166$	$+2{\cdot}0$
Non-Significant	Popliteal Length/Shaft Length	$-0{\cdot}499 \pm {\cdot}264$	$-1{\cdot}9$	Ext. and Int. Condylar Lengths ...	$+0{\cdot}643 \pm {\cdot}342$	$+1{\cdot}9$
	Primary Index of Bowing	$+0{\cdot}072 \pm {\cdot}042$	$+1{\cdot}7$	Robusticity of Head	$+0{\cdot}162 \pm {\cdot}088$	$+1{\cdot}8$
	Ext. Condylar Length/Bicondylar Width	$+0{\cdot}365 \pm {\cdot}221$	$+1{\cdot}7$	Ellipticity of Head	$+0{\cdot}235 \pm {\cdot}131$	$+1{\cdot}8$
	Secondary Index of Neck	$+0{\cdot}389 \pm {\cdot}237$	$+1{\cdot}6$	Bicondylar Width/Trochanteric Length	$+0{\cdot}166 \pm {\cdot}091$	$+1{\cdot}8$
	Capito-collar Length/Shaft Length ...	$-0{\cdot}199 \pm {\cdot}137$	$-1{\cdot}5$	Popliteal Length/Shaft Length	$+0{\cdot}514 \pm {\cdot}312$	$+1{\cdot}6$
	Index of Gracility (Lower)	$-0{\cdot}594 \pm {\cdot}403$	$-1{\cdot}5$	Ext. Condylar Length/Bicondylar Width	$+0{\cdot}497 \pm {\cdot}325$	$+1{\cdot}5$
	Bicondylar Width/Trochanteric Length	$+0{\cdot}102 \pm {\cdot}071$	$+1{\cdot}4$	Bicondylar Width/Maximum Length ...	$+0{\cdot}127 \pm {\cdot}087$	$+1{\cdot}5$
	Robusticity of Head	$+0{\cdot}085 \pm {\cdot}079$	$+1{\cdot}1$	Vertical Diam. of Head/Maximum Length	$+0{\cdot}056 \pm {\cdot}042$	$+1{\cdot}3$
	Secondary Index of Bowing	$+0{\cdot}489 \pm {\cdot}440$	$+1{\cdot}1$	Capito-collar Length/Bicondylar Width	$+1{\cdot}031 \pm {\cdot}848$	$+1{\cdot}2$
				Oblique Length/Maximum Length ...	$-0{\cdot}040 \pm {\cdot}034$	$-1{\cdot}2$
				Popliteal Trans. Diam./Shaft Length ...	$-0{\cdot}052 \pm {\cdot}049$	$-1{\cdot}1$
				Capito-collar Length/Maximum Length	$+0{\cdot}123 \pm {\cdot}127$	$+1{\cdot}0$
	Vert. Diam. of Head/Maximum Length	$+0{\cdot}030 \pm {\cdot}038$	$+0{\cdot}8$	Vert. Diam. of Head/Capito-collar Length	$-0{\cdot}363 \pm {\cdot}431$	$-0{\cdot}8$
	Vert. Diam. of Head/Capito-collar Length	$+0{\cdot}260 \pm {\cdot}370$	$+0{\cdot}7$	Index of Gracility (Upper)	$-0{\cdot}279 \pm {\cdot}391$	$-0{\cdot}7$
	Popliteal Index	$-0{\cdot}298 \pm {\cdot}400$	$-0{\cdot}7$	Capito-collar Length/Oblique Length ...	$+0{\cdot}078 \pm {\cdot}134$	$+0{\cdot}6$
	Ellipticity of Head	$-0{\cdot}084 \pm {\cdot}132$	$-0{\cdot}6$	Secondary Index of Neck	$+0{\cdot}178 \pm {\cdot}277$	$+0{\cdot}6$
	Popliteal Width/Bicondylar Width ...	$-0{\cdot}196 \pm {\cdot}325$	$-0{\cdot}6$	Troch. Oblique Length/Troch. Max. Length	$-0{\cdot}016 \pm {\cdot}043$	$-0{\cdot}4$
	Popliteal A. P. Diam. direct/oblique ...	$-0{\cdot}097 \pm {\cdot}233$	$-0{\cdot}4$	Popliteal Pyramidal	$-0{\cdot}062 \pm {\cdot}333$	$-0{\cdot}2$
	Trochanteric Oblique/Trochanteric Max.	$+0{\cdot}011 \pm {\cdot}030$	$+0{\cdot}4$	Vert. Diam. of Head/Bicondylar Width	$+0{\cdot}013 \pm {\cdot}226$	$+0{\cdot}1$
	Capito-collar Length/Max. Length ...	$-0{\cdot}042 \pm {\cdot}105$	$-0{\cdot}4$	Popliteal Width/Bicondylar Width ...	$-0{\cdot}012 \pm {\cdot}381$	$+0{\cdot}0$
	Platymeric Index	$+0{\cdot}212 \pm {\cdot}556$	$+0{\cdot}4$	Primary Index of Bowing	$+0{\cdot}002 \pm {\cdot}050$	$+0{\cdot}0$
	Capito-collar Length/Oblique Length ...	$-0{\cdot}030 \pm {\cdot}106$	$-0{\cdot}3$			
	Index of Gracility (Upper)	$-0{\cdot}074 \pm {\cdot}334$	$-0{\cdot}2$			
	Pilastric Trans. Diam./Shaft Length ...	$-0{\cdot}001 \pm {\cdot}040$	$-0{\cdot}0$			

the bone that the most conspicuous side-differences occur. We see at once that the index Pilastric A.P. Diameter/Shaft Length, which measures the sagittal slenderness of the bone, is significantly different on right and left sides for both sexes. Again, for both sexes the Pilastric Index is greater on the right side. So also is the Ellipticity of the Neck, the neck being rounder in both sexes on the right side. Further, the Band-radial Index falls into the same category; the right leg appears somewhat better adapted to the upright position than the left, *i.e.* there should be a greater tension in the *ligamentum collaterale fibulare* in the upright relative to the bent knee position in the right than in the left knee joint—the right is less ape-like. The robusticity of the shaft is greater in the right than the left, although more markedly so in males than females. We might, perhaps, expect the indices of gracility to follow the same rule; but there is no significant difference between right and left for the index of upper gracility, while as for the index of lower gracility the right is more gracile than the left and more markedly so in the females than the males. The result suggests that in the robuster bone the popliteal transverse increases at an even greater rate than the pilastric transverse. Possibly also the relative length of the external condyle (External Condylar Length/Trochanteric Length) is greater in the right than the left, although the result appears more markedly in the male than the female. We may further note that in female bones the Secondary Index of Bowing, the Popliteal Index and the Platymeric Index appear to be significantly differentiated on right and left sides, but this is not the case in male bones. A glance at the table given later (p. 142) in this chapter shows that the Secondary Index of Bowing, the Popliteal Index and the Platymeric Index, on the left side at least, are substantially differentiated in the two sexes, and this may conceivably explain why the right and left differences are not as marked in the two sexes.

On the whole while asymmetry is the rule in the human skeleton, the asymmetry is in the individual largely and not in the type. There are relatively few characters of the femur in which we can say there is a definite differentiation between right and left bones, and these characters do not appear to be especially those of absolute length, as various authors have possibly too readily asserted.

(v) *Differences associated with Sex.*

The male is altogether on a larger scale than the female, and the only purpose reached by comparison of absolute length measurements would be to mark those characters which can be most effectively used, as in our Chapter II, for sexual differentiation; to this point we will return later, for it involves not the probable error of mean or type differences, but the separation of the sex distributions. On the other hand, if the female bone were a reproduction on a smaller scale of the male bone we should anticipate that the angles and the indices for the two sexes would remain the same. The divergences accordingly in the angles and indices if significant are especially interesting secondary sexual characters.

We consider first the angles. In the first place we may ask, Should we

anticipate that the angle of torsion would be changed if the female bone, while smaller, were yet similar to the male? The answer would be in the negative, for in similar figures all corresponding lines remain parallel, and hence the *total* angle of torsion would be the same. The osteometrician, unlike the physicist, measures the *total* angle of torsion and not the torsion per unit of length[1]. Accordingly we may include the torsions with our other angles.

TABLE VIII. *Secondary Sexual Differences in Femoral Angles.*

Angle	Right: Male-Female		Left: Male-Female	
	$\Delta_{R.-L.} \pm e_\Delta$	$\Delta_{R.-L.}/e_\Delta$	$\Delta_{R.-L.} \pm e_\Delta$	$\Delta_{R.-L.}/e_\Delta$
Obliquity	− ·706 ± ·145	− 4·9	− ·179 ± ·128	− 1·4
Torsion (sign disregarded) ...	− 2·761 ± ·641	− 4·3	− 2·941 ± ·654	− 4·5
Torsion (sign regarded)	− 2·614 ± ·699	− 3·7	− 3·188 ± ·669	− 4·8
Capital Angle	− ·960 ± ·405	− 2·4	− 1·378 ± ·400	− 3·4
Retorsion	+ 1·661 ± ·768	+ 2·2	+ 2·338 ± ·588	+ 4·0
Collar Angle	+ 1·011 ± ·476	+ 2·1	+ 1·194 ± ·471	+ 2·5
Mid-Trochlear Angle	+ ·071 ± ·090	+ 0·8	+ ·159 ± ·086	+ 1·8
Torsion of Shaft	− ·290 ± ·892	− 0·3	− 2·028 ± ·829	− 2·3

This table has several points of interest. In the first place, whether we regard or disregard the sign of the torsion, there is a significant difference in the total torsion of the femur between male and female. The female bone has the more torsion. In the next place there is little, possibly no difference between male and female in the torsion of the shaft, but in the retorsion, the turning back of the neck and head towards the condylar axis there is a significant difference, the male having a marked preponderance of this form of torsion. Remembering that the anthropoid apes show little torsion, we are more or less forced to connect the greater torsion of mankind with the more erect posture. What is the reason in the case of the female for the excess of torsion being less corrected by the retorsion than in the case of the male? We have suggested in our section on bowing that torsion is like bowing a factor evolved to strengthen the shaft in its plane of minimum resistance as a strut by bringing a diameter greater than the platymeric antero-posterior into that plane[2]. The retorsion is from the standpoint of this suggestion an endeavour to restore the coplanarity of condylar axis and capito-collar axis. Why is this restoration less complete in the case of

[1] In this he acts rightly, because while in physical cases the angle of torsion is usually proportional to the length of a torted member, we shall show later that there is no marked relation between the length of femur or of its shaft and the corresponding torsions.

[2] Thus an elliptic cylinder under compression would be strengthened against buckling in its weakest plane by a torsional set. It would of course be weakened in its strongest plane, which plane would more nearly correspond to the plane of loading in the ape.

the female? We think it must be sought in the fact that in the female pelvis the acetabula have a more frontal, less lateral aspect than in the case of the male pelvis. The more frontal aspect of the acetabula in the female would, we think, be achieved, if, relative to the male, there were a further rotation backward round the axis joining the acetabular centres. Now this involves a lesser inclination to the horizon of the brim of the true pelvis in the female; in other words, the greater torsion of the female, the lesser retorsion, is, if our view be correct, due to a further development of the rotation of the pelvis from the quadrupedal to the bipedal posture; the female is in this sense more erect than the male. With the quadrupeds the acetabula face laterally or slightly fronto-laterally. With the primates their aspect is lateral in *Cercopithecus*, *Ateles*, *Cheirongs* and the chimpanzee, slightly fronto-lateral in *Cynocephalus*, the marmoset, the lemur, and the gibbon, much more fronto-lateral in the orang, and slightly again in the gorilla, while man is more fronto-lateral than any other primate. The Webers and Naegele have measured the inclination of the superior plane of the pelvis (the pelvic brim) to the horizon and give it as 65° for man and about 59°·5 for woman, while the inferior plane or outlet makes an angle with the horizon of about 17° in man and only 10°·5 in woman[1]. These results have been challenged by later writers.

Livius Fürst in a very elaborate memoir of 1875[2] gives the slope of the brim in the male as 48°·4 and in the female as 54°·5, and elaborately terms his first *Abschnitt*: "Historische Uebersicht der bisherigen Anschauungen über die Neigungsverhältnisse des Beckens, u.s.w." He has, however, only dealt with three new, all male, sagittal sections, the rest being taken from the sections published by various authors, and he has adjusted all these not to the individual slopes of the pelvic brim but to the above angles, which he has taken directly from H. Meyer (see Fürst's S. 23). Thus Fürst contributed nothing to the existing knowledge of the *Neigungsverhältnisse*, however valuable his work may be on the form of the fundamental quadrilateral.

If we turn to Meyer's paper of 1861[3] it will be found by no means so conclusive as its elaboration has led many to suppose. It does demonstrate that the pelvic inclination can vary with the momentary attitude of the individual, but Meyer did not measure the pelvic inclination in the living subject as Naegele attempted, but on a preparation consisting of the femora and pelvis in the dissecting room—"Ein Gewicht von einigen Pfunden an das Kreuzbein angehängt unterhält statt der fehlenden Schwere des Rumpfes den Zug des Beckens nach rückwärts" (S. 142). The femora were clamped at the distal end and were capable of rotating round a horizontal axis. Now the assumption made here is

[1] F. C. Naegele, *Das Weibliche Becken*, Karlsruhe, 1825; and W. und E. Weber, *Mechanik der menschl. Gehwerkzeuge*, S. 121, Göttingen, 1836. See also Todd's *Cyclopaedia of Anatomy and Physiology*, Vol. v, p. 133.

[2] *Die Maas- und Neigungs-Verhältnisse des Beckens*, Leipzig, 1875.

[3] Die Beckenneigung, *Reichert u. Du Bois-Raymond's Archiv für Anatomie*, u.s.w., Jahrgang 1861, S. 137—178.

that, however the femora incline to the vertical (and Meyer takes their inclination for *all* individuals and both sexes as 83° to the horizontal in the chief position we have to deal with (S. 171)!), the weight of the body will act as the above weight attached to the sacrum. But not only does this admit of great variation according to the exact point at which it is attached to the sacrum, but the weight of the body is the resultant not only of pressure on the sacrum, but of muscular tensions, and the resultant of this system of forces may for certain positions of the femora not pass through any point of the sacrum at all. But apart from all this if we look at Meyer's actual numbers, say on S. 167 of his memoir, it will be seen that they depend on only nine male and seven female pelves. Also two of these, Male No. 8 and Female No. 6, are undoubtedly anomalous, as Meyer himself seems to recognise at least in one case on S. 170. If we reconstruct therefore Meyer's table on S. 167, omitting ♂ 8 and ♀ 6, we obtain for his five positions:

	Sex	Maximal Positions				Minimum
		1	2	3	4	
Reconstructed means ...	♂	72°·9	97°·0	86°·5	68°·9	42°·9
	♀	71°·0	91°·5	86°·3	67°·2	42°·3
Meyer's means	♂	72°·9	93°·0	82°·0	67°·3	41°·4
	♀	71°·0	94°·4	98°·3	71°·8	45°·0

It will be clear from this table that whatever we think of Meyer's experimental method, his conclusion that the pelvic brim in the female is more inclined than in the male is not justified by his data, for it depends on the presence of a single male and a single extreme female pelvis. In other words, his data are not adequate to finally settle the matter even if his method were unexceptional[1]. Waldeyer in his classical work on the pelvis[2] avoids the controversy by giving the pelvic inclination for the female only. Until the whole is reconsidered with wider material and more exact methods we shall continue to accept the view which flows from Naegele's and the Webers' observations, namely that in the upright position the female pelvis appears to be tilted further backwards round the acetabular axis than the male. This sexual difference in man is wholly in accordance with the usual diagrams of male and female pelves "seen from before in the erect posture" to be found in the anatomical text-books and also with what Broek[3] has noticed in *Cebus*, *Macacus cynomolgus*, *Hylobates syndactylus* and gorilla. Accordingly it is probably a sexual differentiation arising

[1] Statistically no result is valid when it can be reversed by the subtraction or addition of a single individual from the compared groups.

[2] *Das Becken*, Bonn, 1899.

[3] *Archiv für Anatomie und Physiologie* (*Anatomie*), Jahrgang 1911, S. 163 et seq.

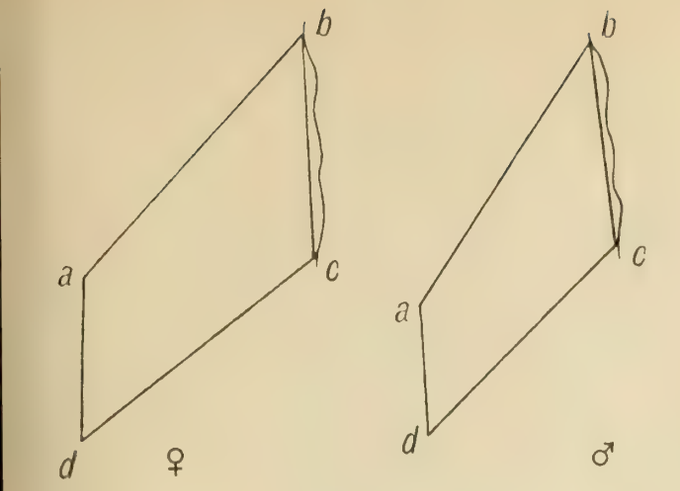


FIG. (I). CEBUS.

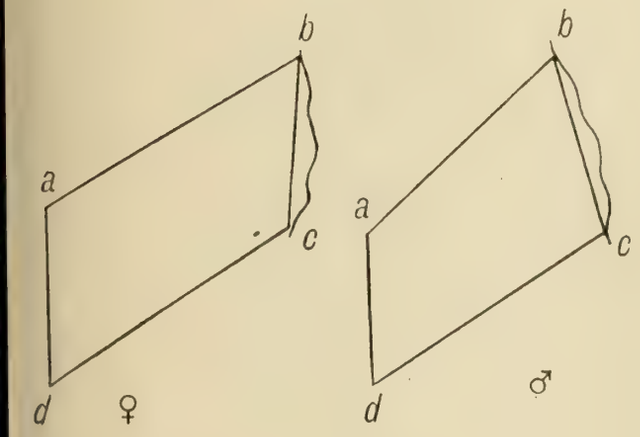


FIG. (II). MACACUS CYNOMOLGUS.

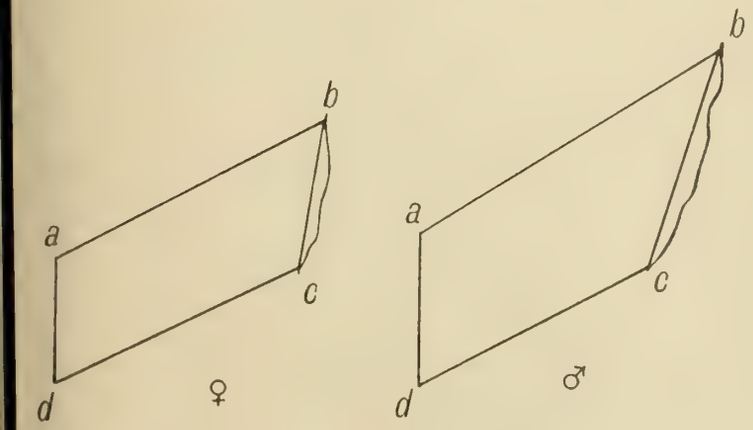


FIG. (III). HYLOBATES SYNDACTYLUS.

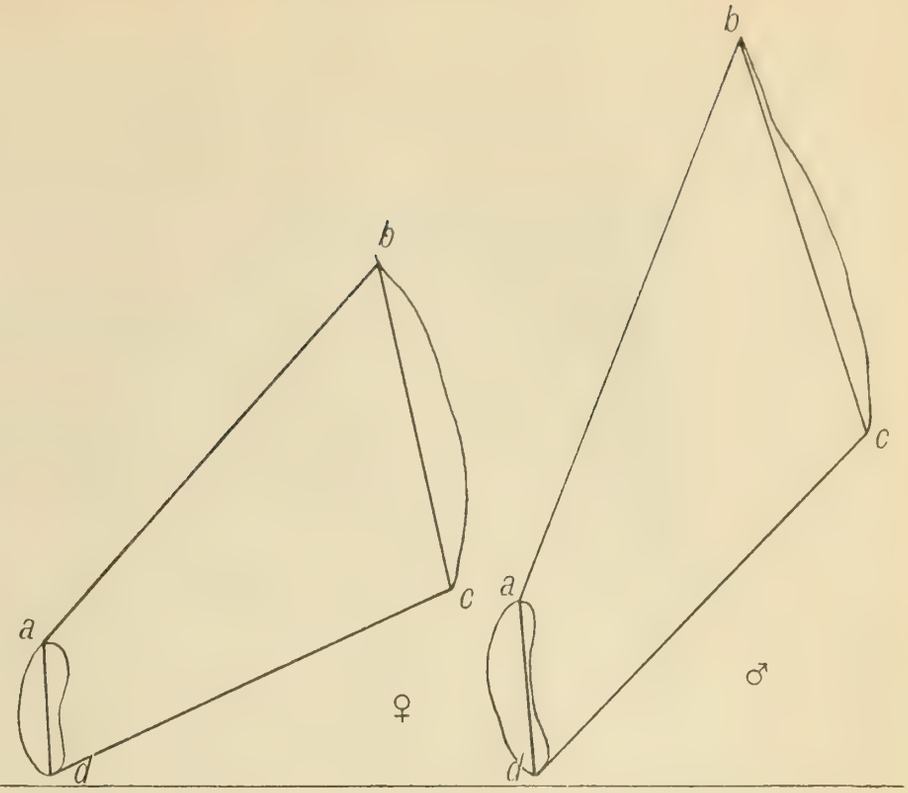


FIG. (IV). TROGLODYTES GORILLA.

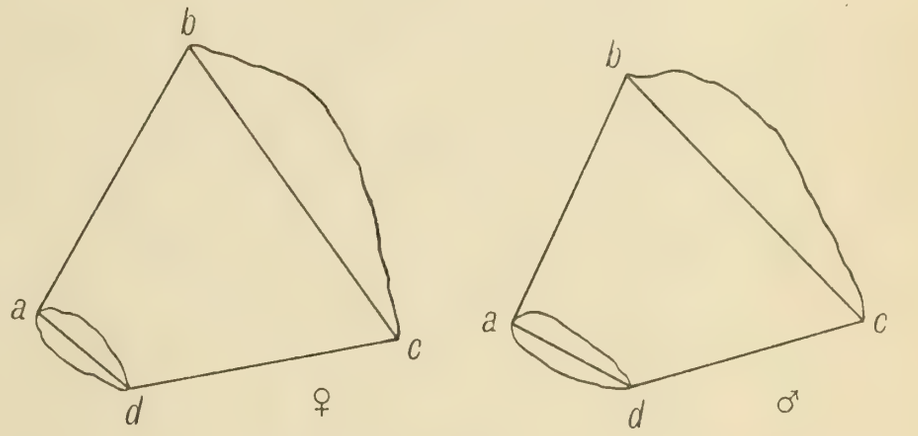


FIG. (V). HOMO SAPIENS.

LENGTH FROM TOP OF SACRUM TO TOP OF SYMPHYSIS *ab*.
ROUND NUMBERS.

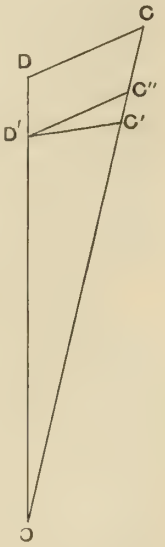
CEBUS *ab* = 5 CMS.
MACACUS *ab* = 7 CMS.
GIBBON *ab* = 8 CMS.
GORILLA *ab* = 21·5 CMS.
MAN *ab* = ♂, 11·4 = ♀, 10·2 CMS.

a = UPPER BORDER OF SYMPHYSIS.
b = PROMONTORY OF SACRUM.
c = TIP OF COCCYX.
d = APEX OF SUBPUBIC ANGLE.

FUNDAMENTAL QUADRILATERAL OF MESIAL PELVIC SECTION ((I) TO (IV) AFTER BROEK, (V) PEARSON), SHOWING APPROXIMATE ORIENTATION WITH REGARD TO THE HORIZONTAL OF PELVIC BRIM, *ab*, IN MALE AND FEMALE.

anterior to the racial differentiation. If we ask why does this further tilting backwards of the pelvis occur in the female, some answer may possibly be found in the posture of the female during pregnancy. Fick[1] gives, after Kuknow, a diagram showing how in the majority of cases the pregnant woman throws the entire body backwards round the ankle joint. Such a rotation must of course be accompanied by an increase in the horizontality of the pelvic brim. The suggestion we make is that the greater tilt from the quadrupedal position of the female pelvis is to be associated with the child-bearing function of the female; it is a permanent sexual feature of the exaggerated vertical posture in pregnancy. It has been suggested that the greater horizontality of the pelvic brim in woman is inconsistent with greater lumbar protrusion in the female. Apart from the question of sexual difference in the deposition of fat, the greater sacro-pelvic angle in the female[2] would to some extent balance this tilting of the pelvic brim. Whether or not we can thus through a chain of linked relations associate the lesser retorsion of the female femur with the needs of posture in pregnancy, there can be still little doubt that this lesser retorsion of the female femur is precisely what we should anticipate from the more anterior aspect of the acetabula of the pelvis in that sex.

While the torsion of the shaft and the midtrochlear angle of the fundamental triangle appear to have no definitely significant relation to sex, the other two angles of the fundamental triangle appear to be definitely differentiated; the collar angle is greater and the capital angle less in the male than the female. Thus while the capito-collar axis is depressed in the female, the shortening of the length of this axis is such that the midtrochlear angle remains unchanged. This must signify that the index capito-collar length/shaft length is less in the female than the male, and this is actually the case[3]. Thus if *ODC* be the fundamental triangle for the male sex, *OD′C″* would represent the same triangle for the female on the basis of mere reduction in size. Actually the capito-collar axis is depressed so that *C* moves as to *C′* approximately along *CO*, and the capito-collar shaft index is thus reduced.



Lastly, the obliquity is sensibly greater in the female right than the male right; in the left femur they are more nearly equal, although the sign being the same as in the right we may reasonably suppose the greater female obliquity to be maintained if at a less predominance. The increased obliquity of the female femur tends to compensate for the reduced collar angle, for it tends to bring the capito-collar axis back to the same inclination to the horizon in the two sexes, although it fails to achieve this fully.

[1] *Handbuch der Anatomie und Mechanik der Gelenke*, Theil III, S. 59, Jena, 1911.

[2] Le Damany, *Journal de l'Anatomie et de la Physiologie*, Tom. XLII, p. 180, Paris, 1906. Todd, *l.c.* p. 134, gives data bearing against the view, however, that the sacrum projects more from the vertebral column in females than males.

[3] Capito-collar-shaft Index: ♂, R. = 20·4, ♀, R. = 19·8, ♂, L. = 20·58, ♀, L. = 19·5.

We now turn to the femoral indices to see what other secondary sexual characters than pure size may be noted in the femur. The table on p. 142 gives the differences and the probable errors of the differences.

Now this table is really remarkable. So far from the female femur being only different from the male in *size*, we find that only sixteen out of sixty-six indices calculated fail to be either probably or possibly differentiated. In other words, sexual differences in *shape* are very marked indeed, and this is in accordance with what we have already learnt of the angles of the femur. Starting with those characters in which we find no significant sexual difference in either right or left member, we note that:

(i) neither man nor woman is significantly nearer the ape as nearness is measured by the band-radial index;

(ii) neither man nor woman is significantly nearer palaeolithic man as measured by the primary index of bowing (iii) nor by less gracility in the upper half of the shaft;

(iv) the relative horizontal thickness of neck and head is not different in the two sexes.

Again we may reasonably treat as non-significant characters which are non-significant for one member and only possibly significant for the other. Such characters are: (v) Index of Gracility of the lower half of the shaft, (vi) the ratio of the two condylar lengths, (vii) the shape of the popliteal section as measured by the Index of Popliteal Skewness, (viii) the Popliteal Pyramidal Index, (ix) the Soffit Index, or the supra-condylar contraction as measured by the ratio of popliteal to bicondylar width, (x) the proportion the popliteal surface bears to the total shaft, and (xi) the ratio of proximal to distal epiphysial size as measured by the index of capito-collar length to bicondylar width or the Epiphysial Ratio.

It is worthy of special attention that the characters (v) to (xi) just enumerated include the chief of those which have, like (i) to (iv), either been used, or indeed especially introduced to measure the divergence of modern man from primitive man and from pithecoid types. So far as our data for the femur go they do not confirm the views that have been propounded by certain authors that the sexes differ by arrested development or that one sex is more primitive or more apelike than the other. Those characters in which we cannot assert sexual differentiation in man are largely those in which man is most markedly differentiated from his progenitors and early collaterals.

It is not of course asserted that the latter characters cease when we pass into the range of probably and certainly significant differences. The indices of transverse and sagittal slenderness, the ellipticity of the neck, the indices of robusticity of the head and shaft may be undoubtedly used for racial differentiation, but roughly it would appear that the indices with most sexual differentiation are those with less racial differentiation and *vice versa*. Nor is this on the whole to be wondered at, if we remember that sexual differentiation antedates racial differentiation, thus the sexual differentiation of the pelvis is closely alike

TABLE IX. *Differences of the Indices in Male and Female Femora for Left and Right Sides.*

Nature of Difference	Right			Left		
	Index	$\Delta_{\sigma-\varphi} \pm e_\Delta$	$\frac{\Delta_{\sigma-\varphi}}{e_\Delta}$	Index	$\Delta_{\sigma-\varphi} \pm e_\Delta$	$\frac{\Delta_{\sigma-\varphi}}{e_\Delta}$
Most markedly significant	Vert. Diam. of Head/Maximum Length	+0·443 ± ·040	11·1	Vert. Diam. of Head/Maximum Length	+0·469 ± ·040	11·7
	Robusticity of Head	+0·807 ± ·087	9·3	Secondary Index of Bowing	−6·021 ± ·549	−11·0
	Popliteal Index	+3·630 ± ·402	9·0	Robusticity of Head	+0·884 ± ·081	10·9
	Bicondylar Width/Maximum Length ...	+0·624 ± ·080	7·8	Pilastric A. P. Diam./Shaft Length ...	+0·386 ± ·039	9·9
	Pilastric A. P. Diam./Shaft Length ...	+0·320 ± ·044	7·3	Bicondylar Width/Trochanteric Length	+0·666 ± ·079	8·4
	Bicondylar Width/Trochanteric Length	+0·602 ± ·084	7·2	Capito-collar Length/Shaft Length ...	+1·126 ± ·145	7·8
	Ext. Condylar Length/Bicondylar Width	−1·915 ± ·297	−6·4	Bicondylar Width/Maximum Length ...	+0·549 ± ·073	7·5
				Ext. Condylar Length/Bicondylar Width	−1·783 ± ·257	−6·9
				Pilastric Index	+3·655 ± ·603	6·1
				Platymeric Index	+3·365 ± ·564	6·0
				Vert. Diam. of Head/Bicondylar Width	+1·012 ± ·196	5·2
Very significant	Index of Robusticity	+0·315 ± ·059	5·3	Capito-collar Length/Maximum Length	+0·667 ± ·116	5·8
	Capito-collar Length/Maximum Length	+0·502 ± ·117	4·3	Popliteal Index	+2·233 ± ·400	5·6
	Capito-collar Length/Oblique Length ...	+0·511 ± ·123	4·2	Capito-collar Length/Oblique Length ...	+0·619 ± ·119	5·2
	Secondary Index of Bowing	−2·376 ± ·563	−4·2	Index of Robusticity	+0·233 ± ·055	4·2
				Oblique Length/Maximum Length ...	+0·119 ± ·030	4·0
Probably significant	Pilastric Trans. Diam./Shaft Length ...	+0·181 ± ·046	3·9	Ellipticity of Neck	−1·299 ± ·335	−3·9
	Capito-collar Length/Shaft Length ...	+0·590 ± ·160	3·7	Troch. Oblique Length/Troch. Max. Length	+0·114 ± ·034	3·4
	Troch. Oblique/Troch. Maximum Length	+0·141 ± ·040	3·5	Ext. Condylar Length/Troch. Length ...	+0·179 ± ·056	3·2
	External Condylar Length/Troch. Length	+0·187 ± ·057	3·3	Pilastric Trans. Diam./Shaft Length ...	+0·130 ± ·044	3·0
	Pilastric Index	+1·956 ± ·618	3·2			
	Ellipticity of Head	−0·414 ± ·137	−3·0			
	Ellipticity of Neck	−1·205 ± ·408	−3·0			
Possibly significant	Soffit Index	−0·966 ± ·359	−2·7	Capito-collar Length/Bicondylar Width	+1·932 ± ·684	2·8
	Vert. Diam. of Head/Bicondylar Width	+0·577 ± ·215	2·7	Popliteal Length/Shaft Length	+0·789 ± ·287	2·7
	Index of Popliteal Skewness	+0·672 ± ·251	2·7	Soffit Index	−0·782 ± ·349	−2·2
	Oblique Length/Maximum Length ...	+0·085 ± ·032	2·7	Ext. Condylar Length/Internal ditto ...	−0·591 ± ·297	−2·0
	Index of Gracility (Lower)	+1·002 ± ·422	2·4			
	Vert. Diam. of Head/Capito-collar Length	+0·938 ± ·410	2·3			
	Popliteal Pyramidal Index	+0 627 ± ·311	2·0			
	Platymeric Index	+1·245 ± ·618	2·0			
Non-significant	Primary Index of Bowing	+0·084 ± ·048	1·8	Neck-Head Index	−0·418 ± ·252	−1·7
	Ext. Condylar Length/Internal ditto ...	−0·310 ± ·310	−1·0	Index of Gracility (Lower)	−0·408 ± ·438	−0·9
	Capito-collar Length/Bicondylar Width	−0·698 ± ·820	−0·9	Ellipticity of Head	−0·095 ± ·125	−0·8
	Index of Gracility (Upper)	+0·341 ± ·380	0·9	V. D. of Head/Capito-collar Length ...	+0·315 ± ·393	0·8
	Neck-Head Index	−0·207 ± ·264	−0·8	Popliteal Pyramidal Index	−0·177 ± ·308	−0·6
	Popliteal Length/Shaft Length	−0·224 ± ·291	−0·8	Index of Gracility (Upper)	+0·136 + ·346	0·4
	Band-radial Index	+0·431 ± ·934	0·5	Index of Popliteal Skewness	+0·116 + ·259	0·4
				Primary Index of Bowing	+0·014 ± ·044	0·3
				Band-radial Index	+0·193 ± ·863	0·2

for man and the anthropoid apes[1], but, for this likeness to exist, it must occur in those characters chiefly in which man and the apes are not markedly differentiated.

The reader who has examined the table on p. 142 carefully will certainly have noted that while in the non-significant group the plus and minus signs are equally distributed, *i.e.* in 50°/₀ of cases the index for the males exceeds and in 50°/₀ of cases it falls short of the index for the females; this is far from being the fact for the fifty indices which have possibly, probably or certainly significant differentiation. Only ten of these indices are negative, and this very large preponderance of male indices over female is obviously a matter which requires elucidation. Let us consider first the nature of the indices in which the female has a preponderance over the male. They are

(i) *Ellipticity of the Head.* (R. and L.) The two diameters of the head are nearly equal; all the indices are about 99.

(ii) *Secondary Index of Bowing.* (R. and L.) In this case the index measures the position of a certain point in an arc and can hardly be described as the ratio of two more or less independent lengths.

(iii) *Condylar Lengths Index.* (R. and L.) This only reaches the possibly significant on the left-side, although it is negative on the right. The values of all four indices are about 100, *i.e.* the lengths of the two condyles are nearly equal.

(iv) *External Condylar Length / Bicondylar Width.* Here the female has a most markedly greater index than the male. While her external condyle is 10°/₀ less than that of the male in length, her bicondylar width is no less than 12°/₀ less. Thus the greater length has in this case the more marked reduction. But we must bear in mind that the bicondylar width is not like the bulk of our measurements on the femur, an actual length of bone material; it spans as a rule (see Diagram D, Plate III) the intercondylar notch, and accordingly its magnitude depends largely on the slope of the condyles—especially the internal condyle—to the sagittal plane. Unfortunately we have not taken the oblique length of the internal condyle, but taking the less inclined external condyle, we find that *roughly* it is inclined at about 11° to the sagittal plane in the male and at about 9° in the female. In other words, if the external condyles were of the same dimensions in male and female the female bicondylar width would be less owing to the external condyle in the male having a greater slope to the sagittal plane. There is small doubt that in the male femur the internal condyle slopes more than the female to the same plane. But apart from this the length of the internal condyle in the female is relative to the length of the external condyle smaller in the female. In other words, if the internal condyles in male and female had the same slope, the female bicondylar width would be less than the male. Accordingly, if all lengths in the female femur were the same percentage less than the male, yet the bicondylar width would be reduced at a greater percentage owing to the sexual difference of the posture of the condyles to the sagittal plane. Thus the

[1] See the Diagram, p. 138.

bicondylar width cannot be looked upon as measurement homologous with other femoral measurements.

(v) *Soffit Index,* or *Popliteal Width / Bicondylar Width.* This index is only "possibly significant" in both members. Yet the same remarks as in (iv) apply here. The popliteal width has been decreased about 10 °/₀, but the bicondylar width by about 12 °/₀ as we pass from male to female.

(vi) *Ellipticity of the Neck.* The vertical diameter is here greater than the horizontal, the value of the ellipticity being about 76. Hence we have a real exception to the rule we are about to propound. Actually the horizontal diameter of the neck is reduced in the female about 11·9 °/₀, while the vertical is reduced about 13·5 °/₀, thus giving the female a greater index. The ellipticity of the neck appears to be, however, the only true exception to our rule, and of this it must be said that it is an index formed from two *short* lengths.

Now we have seen that the female is not a merely reduced male. The female femur is not merely reduced in size, but markedly in shape. But in quantitatively determining shape we use indices which are the ratios almost invariably of a smaller length to a larger length. Now if the male index when significantly different from the female be almost invariably larger than the female index, it must follow that the reduction in size from male to female obeys the following law :

The diminution of size in any length of the femur as we pass from male to female is not uniform, but is greater for the smaller dimensions.

In other words, since our general conception of the measurements of slenderness and gracility is a small dimension by a large dimension, we conclude that the study of the indices demonstrates quantitatively that the female femur does not resemble a smaller male but is relatively more slender and gracile in its component parts.

The table on p. 145 indicates this fundamental law in more detail. It will be clear from this table that while size of character is a large factor in determining amount of female reduction, it is not the sole factor. In particular the smaller reductions in the cases of platymeric transverse diameter, pilastric transverse diameter and popliteal width indicate that for small lengths in the direction perpendicular to the sagittal plane the reduction is not so great as in the case of small lengths perpendicular to the standard vertical plane. The general effect, however, is as we have stated, the longer lengths have least percentage reduction and accordingly the bulk of the male indices are greater in value than the female indices.

One of the other points which flows from our classification of sexual differences in the femoral indices is that in most cases these indices are differentiated and that accordingly it is not legitimate, as several authors have done in the past, to club the two sexes together when dealing with the platymeric, pilastric and popliteal indices.

It will be noted that sex-ratio for the various *size* characters of the femur varies from 1·084 for the length of the shaft to 1·156 for the minimum vertical diameter of the neck. It is probably less for other components of stature than the femur. For the maximum length of femur the sex-ratio is 1·093, and for the

TABLE X. *Percentage reduction of Male character needful to obtain corresponding Female character.*

Femoral Character	Mean in mm. of Males Right and Left values	Mean, Right and Left Percentage Reduction
Maximum Length	447·24	8·50
Oblique Length	449·42	8·79
Maximum Trochanteric Length	434·60	8·47
Capito-Trochlear Length	432·28	8·85
Trochanteric Length	425·81	8·62
Trochanteric Oblique Length	423·50	8·92
Length of Shaft	377·09	7·78
Diaphysial Chord	252·70	10·03
Popliteal Length	121·74	8·71
Bicondylar Width	79·78	12·24
Capito-collar Length	77·12	11·97
Maximum Length, External Condyle	62·44	10·12
Maximum Length, Internal Condyle	62·06	10·46
Oblique Length, External Condyle	61·45	9·70
Vertical Diameter of Head	46·91	12·72
Horizontal Diameter of Head	46·49	12·65
Popliteal Width	39·65	9·48
Minimum Vertical Diameter of Neck	34·04	13·49
Platymeric Transverse Diameter	31·60	9·40
Popliteal Antero-posterior Oblique Diameter	30·79	12·68
Pilastric Antero-posterior Diameter	29·10	12·12
Pilastric Transverse Diameter	27·99	9·67
Popliteal Antero-posterior Direct Diameter	27·92	12·87
Platymeric Antero-posterior Diameter	26·74	11·82
Minimum Horizontal Diameter of Neck	25·68	11·94
External Condyle, Vertical Band-radius	20·82	11·26
External Condyle, Horizontal Band-radius	18·89	11·02
Diaphysial Subtense	6·49	11·65

oblique length 1·096. But Galton[1] gives it on his data for stature as 1·08, while Lee and Pearson[2] found it for stature on the average of about 1000 cases for each generation 1·083 for the older and 1·075 for the younger generation, agreeing in their mean closely with Galton's value.

We have left till the last all discussion of the sexual differences in absolute size, for these are so well recognised that they have less of interest than the shape differences. But we give a table of them on p. 146 marshalled in order of their significance. The significance may be judged by the multiple the difference is of the probable error of that difference, and this is the most direct method of determining the relative magnitude of the sexual difference in type; or by the ratio of the difference of the means to the square root of the sum of the squares of the standard deviations of the character in the two sexes, which is a good measure of how far the distributions round the means are segregated and so the character capable of being used effectively as a sex discriminant.

[1] F. Galton, *Natural Inheritance*, p. 78, London, 1889.

[2] *Biometrika*, Vol. II, p. 370.

It will be seen at once that:

(i) the means of the absolute characters except in group E, which contains the angles, are conspicuously differentiated, the male being in every character of Groups A—D larger than the female;

(ii) the separation of the frequency distributions as measured by the ratio of the difference between their means to the square root of the sum of the squares of the standard deviations[1] is never very marked, its largest value falling short of two (1·91, in the case of the bicondylar width of the right femur).

Thus while the male and female *types* are markedly differentiated, there will in any case be something like 1 femur in 150 of one sex which is above or below, as the case may be, the type of the other sex, and accordingly at a minimum for the most markedly differentiated character nearly 50 °/₀ of the femora of one sex will fall into the range of the variation of the femora of the other sex. We cannot hope therefore adequately to sex the individual femur in more than about 50 °/₀ of cases at most by appeal to any one single character.

The best characters for sexing are those of Group A. They are the diameters of the head, bicondylar width, the antero-posterior dimensions of the condyles, and the minimum vertical diameter of the neck. Since the diameters of the head are very highly correlated and also the lengths of the condyles, we may take the four characters, (i) Bicondylar Width, (ii) Horizontal Diameter of Head, (iii) Oblique Length of External Condyle[2] and (iv) Minimum Vertical Diameter of the Neck, as the best characters for sexing. Our second Group B falls considerably behind the above except (iv), and substantially represents difference in the longitudinal measurements. Probably the Oblique Length and the Oblique Trochanteric Length are the best characters in this group, and again as they are highly correlated together it would be sufficient if any at all are considered to take the oblique length. Group D would clearly be of no service at all for sexing, for the best characters would give 8 °/₀ about of one sex below or above the type of the other, and the worst as much even as 34 °/₀. Group C does not consist of a fairly homogeneous class of characters like Groups A and B, but of a mixture of small diameters and medium lengths, *e.g.* shaft length, diaphysial chord and capito-collar length. The latter fall at the bottom of the group and are practically useless for sexing purposes. The three main antero-posterior diameters of the popliteal region—with which the popliteal oblique antero-posterior diameter may be included from Group B—have about equal sexing value with the horizontal diameter of the neck. But their values are very considerably below the lengths of Group B, and we do not think much insight could be obtained as to sex by their inspection. General appreciation of sex apart from muscular characters is best given by a study of the dimensions of the condyles and head and neck, taken

[1] We do not justify this measure of separation at present on theoretical grounds—it is clearly quite a good practical measure of distribution separation.

[2] "Height of condyle above table" in the standard position of the bone. This is easier to measure and less frequently damaged than the maximum length.

TABLE XI. *The Ranks of Male and Female absolute Character Differences for Right and Left Femur.*

Group	Character	Right					Left				
		$\Delta_{\delta-\varphi} \pm e_\Delta$	Σ	Rank $\frac{\Delta_{\delta-\varphi}}{e_\Delta}$		Rank $\frac{\Delta_{\delta-\varphi}}{\Sigma}$		$\Delta_{\delta-\varphi} \pm e_\Delta$	Σ	Rank $\frac{\Delta_{\delta-\varphi}}{e_\Delta}$		Rank $\frac{\Delta_{\delta-\varphi}}{\Sigma}$	
A	Vertical Diameter of Head ...	+ 5·936 ± ·177	3·56	33·5	1	1·67	3	+ 6·004 ± ·167	3·44	36·0	1	1·75	3
	Horizontal Diameter of Head ...	+ 5·886 ± ·185	3·48	31·8	2	1·69	2	+ 5·878 ± ·165	3·27	35·6	2	1·80	1
	Bicondylar Width	+ 10·024 ± ·315	5·26	31·8	3	1·91	1	+ 9·518 ± ·306	5·37	31·1	4	1·77	2
	External Condyle, Oblique Length	+ 6·042 ± ·207	4·06	29·2	4	1·49	5	+ 5·881 ± ·193	3·90	30·5	5	1·51	5
	External Condyle, Max. Length ...	+ 6·376 ± ·219	4·19	29·0	5	1·52	4	+ 6·265 ± ·209	4·03	30·0	6	1·55	4
	Internal Condyle, Max. Length ...	+ 6·542 ± ·231	4·61	28·3	6	1·42	6	+ 6·449 ± ·225	4·57	28·7	7	1·41	7
	Vertical Diameter of Neck	+ 4·472 ± ·160	3·35	28·0	7	1·33	8	+ 4·716 ± ·151	3·29	31·2	3	1·43	6
B	Popliteal Oblique A. P. Diam. ...	+ 3·972 ± ·153	3·26	26·0	8	1·22	14	+ 3·811 ± ·148	3·20	25·8	13	1·19	15
	Oblique Length	+ 37·926 ± 1·484	29·57	25·6	9	1·28	10	+ 40·271 ± 1·489	30·45	27·1	10	1·32	8
	Capito-Trochlear Length	+ 38·046 ± 1·490	30·77	25·5	10	1·24	12	+ 38 466 ± 1·394	29·56	27·6	9	1·30	9
	Trochanteric Length	+ 36·400 ± 1·440	28·13	25·3	11	1·29	9	+ 37·019 ± 1·436	28·96	25·8	12	1·28	13
	Maximum Length	+ 36·657 ± 1·452	30·01	25·3	12	1·22	13	+ 39·443 ± 1·456	30·67	27·0	11	1·29	11
	Max. Trochanteric Length	+ 37·498 ± 1·507	28·29	24·9	13	1·27	11	+ 36·159 ± 1·491	29·74	24·3	16	1·22	14
	Oblique Trochanteric Length ...	+ 38·002 ± 1·536	28·20	24·7	14	1·35	7	+ 37·563 ± 1·496	29·00	25·1	15	1·30	10
C	Platymeric A. P. Diam.	+ 3·011 ± ·122	2·59	24·7	15	1·16	15	+ 3·307 ± ·117	2·58	28·3	8	1·28	12
	Pilastric A. P. Diam.	+ 3·483 ± ·142	3·05	24·5	16	1·14	16	+ 3·511 ± ·145	3·21	24·2	17	1·09	18
	Popliteal Direct A. P. Diam. ...	+ 3·696 ± ·160	3·37	23·1	17	1·10	17	+ 3·489 ± ·147	3·21	23·7	18	1·09	17
	Horizontal Diameter of Neck ...	+ 2·989 ± ·134	2·78	22·3	18	1·08	18	+ 3·143 ± ·125	2·70	25·1	14	1·16	16
	Length of Shaft	+ 30·097 ± 1·421	29·26	21·2	19	1·03	19	+ 28·599 ± 1·316	27·98	21·7	21	1·02	20
	Pilastric Trans. Diam.	+ 2·828 ± ·136	2·92	20·8	20	·97	21	+ 2·583 ± ·132	2·89	19·6	22	·89	23
	Diaphysial Chord	+ 24·017 ± 1·268	26·59	18·9	21	·90	23	+ 26·677 ± 1·225	26·54	21·8	20	1·01	22
	Capito-collar Length	+ 2·699 ± ·458	9·54	18·9	22	·91	22	+ 9·816 ± ·438	9·29	22·9	19	1·06	19
D	External Condyle, Vert. Band-radius	+ 2·344 ± ·137	2·42	17·1	23	·97	20	+ 2·348 ± ·130	2·33	18·1	23	1·01	21
	Platymeric Trans. Diam.	+ 3·105 ± ·183	3·91	17·0	24	·79	25	+ 2·840 ± ·162	3·58	17·5	24	·79	25
	Popliteal Breadth	+ 3·554 ± ·245	5·23	14·5	25	·68	26	+ 3·962 ± ·233	5·04	17·0	25	·79	26
	External Condyle, Horiz. Band-radius	+ 2·060 ± ·147	2·54	14·0	26	·81	24	+ 2·104 ± ·138	2·44	15·3	26	·86	24
	Popliteal Length	+ 9·120 ± 1·062	22·59	8·6	27	·40	27	+ 12·095 ± 1·022	22·17	11·8	27	·55	27
	Diaphysial Subtense	+ 0·794 ± ·120	2·53	6·6	28	·31	28	+ 0·718 ± ·111	2·41	6·5	28	·30	28
E	Obliquity of Shaft	− 0·706 ± ·145	2·94	4·9	29	·24	29	− 0·179 ± ·128	2·67	1·4	36	·07	36
	Torsional Angle (sign disregarded)	− 2·761 ± ·641	12·34	4·3	30	·22	30	− 2·941 ± ·654	13·04	4·5	30	·23	30
	Torsional Angle (sign regarded) ...	− 2·614 ± ·699	13·45	3·7	31	·19	31	− 3·188 ± ·699	13·37	4·8	29	·24	29
	Angle at Centre of Head	− 0·960 ± ·405	8·27	2·4	32	·12	32	− 1·378 ± ·400	8·37	3·4	32	·16	32
	Retorsional Angle	+ 1·661 ± ·768	14·61	2·2	33	·11	33	+ 2·338 ± ·588	11·50	4·0	31	·20	31
	Angle of Neck and Shaft	+ 1·011 ± ·476	9·75	2·1	34	·10	34	+ 1·194 ± ·471	9·87	2·5	33	·12	33
	Angle at Midtrochlear Point ...	+ 0·071 ± ·090	1·85	0·8	35	·04	35	+ 0·159 ± ·086	1·80	1·9	35	·09	35
	Torsion of Shaft	− 0·290 ± ·892	17·44	0·3	36	·02	36	− 2·028 ± ·829	16·77	2·5	34	·12	34

in conjunction with the oblique length as a factor of secondary importance. It will be seen that the diameter of the head does not stand alone and is by no means so conclusive as some anatomists would have us believe; the bicondylar width is somewhat better and the oblique length of the external condyle and the minimum vertical diameter of the neck are quite good factors of sex appreciation also.

In dealing, however, with the bicondylar width, the oblique length of the external condyle and the vertical diameters of neck and head as probably the best sexing characters[1], we must constantly bear in mind that they are not independent but highly correlated characters. Hence judgments based on these four characters will not be themselves of independent weight. We propose to enter a little further into these correlations. If we suppose appreciation of sex—not actual sex—to be a graduated character and assume for it a normal distribution, then we might determine the correlation between appreciation of sex and a given character by the biserial process. A consideration, however, arises here from selective influences which may tend to reduce the number of female relative to the number of male bones preserved. It would be a more reasonable hypothesis to suppose the number of male and female bones approximately equal in an actual population and for such a population biserial r will differ considerably from the selected population. Since selection is also probably of the more slender bones the means and possibly the standard deviations of male and female may be varied. It is difficult to see how this in the present state of our knowledge can be *fully* allowed for, and we usually speak of the male and female means and standard deviations as if they were those of an unselected population. All we can do here is to rectify the size of the male and female series by making them sensibly equal. In this case if $\bar{m}$ be the mean, and σ the standard deviation of the total population, m_m, m_f, σ_m, σ_f those of males and females respectively, we have

$$\bar{m} = \tfrac{1}{2}(m_m + m_f),$$

$$\sigma^2 = \tfrac{1}{2}(\sigma_m{}^2 + \sigma_f{}^2) + \tfrac{1}{4}(m_m - m_f)^2.$$

Hence biserial r, since $z/\frac{1}{2}(1-\alpha) = \cdot 797{,}8846$, will be found to be given by

$$r = 1\cdot 253{,}314 \times \frac{\frac{1}{2}(m_m - m_f)}{\sqrt{\frac{1}{2}(\sigma_m{}^2 + \sigma_f{}^2) + \frac{1}{4}(m_m - m_f)^2}}.$$

[1] The reader may ask why only two of the above characters were used in our discussion of the mathematical sexing in Chapter II. The answer is that at the time of the mathematical sexing no anatomical sexing nor even an anatomical examination of the bones had been made; the mathematical sexing was made on the massed data provided by the measurers and the anatomical sexing was taken at a much later date. Thus there was no *a priori* guide except such statements as those of Dwight as to what characters were likely to prove of value, and the great labour involved in the process enforced a narrow selection of about twelve characters. It was only after the mathematical was found in accord with the general anatomical appreciation of sex that we could then proceed to investigate the best sexing characters on the basis of the actually sexed bones.

We propose to apply this formula to the following data:

Characters	Means				Standard Deviations			
	R. ♂	L. ♂	R. ♀	L. ♀	R. ♂	L. ♂	R. ♀	L. ♀
Bicondylar Width	80·147	79·404	70·123	69·886	4·025	4·109	3·393	3·458
Vertical Diameter of Head ...	47·059	46·769	41·123	40·765	2·887	2·797	2·077	2·000
Ext. Condyle, Oblique Length...	61·846	61·048	55·804	55·167	3·073	3·116	2·659	2·340
Vertical Diameter of Neck ...	33·849	34·236	29·377	29·520	2·695	2·635	1·982	1·965

In the accompanying table we give the results for the biserial correlations[1] of sex with various characters:

Characters Sex with:	Right		Left		Mean of R.+L.	
	Equal Sex Totals	Observed Sex Totals	Equal Sex Totals	Observed Sex Totals	Equal Sex Totals	Observed Sex Totals
Bicondylar Width	1·0062(?)	1·0269(?)	·9797	·9784	·9929	1·0026(?)
Vertical Diameter of Head ...	·9562	·9641	·9739	·9590	·9650	·9615
Ext. Condyle, Oblique Length	·9081	·9041	·9145	·9063	·9113	·9052
Vertical Diameter of Neck ...	·8609	·8509	·8926	·8858	·8817	·8683

Now we observe at once: (i) That the order of importance for sex differentiation is precisely that of our table on p. 147. In other words the bicondylar width is the most important sexual character, the vertical diameter of the head the next, followed by the oblique length of the external condyle and close to it the vertical diameter of the neck. (ii) That in one case, that of the bicondylar width, the correlation just exceeds unity, and is therefore impossible. This has occurred before although very rarely, *i.e.* when the correlation is exceedingly high the deviation of the material from a true Gaussian distribution may be such that the biserial value may just exceed unity. Theoretically of course for a true Gaussian distribution the correlation could only be perfect if the male and female series never overlapped. That they do overlap shows that the correlation although very high cannot be perfect, much less greater than unity. Hence the observed result must be due to either systematic or random deviation from the Gaussian frequency[2]. (iii) That on

[1] Increasing size of character with increasing certitude of maleness is taken as a *positive* correlation.

[2] We tried a number of expedients in our endeavours to ascertain the probable source of the discrepancy other than the influence of disturbing factors on *very high* correlation. (i) We omitted all bones in which we had marked the bicondylar width with a query. This reduced our ♂ R. bones to 136 and ♀ R. to 88, and biserial r came out 1·0073. The result therefore is hardly due to the retention

the whole very slight (although sensible) changes are made when we correct the observed sex totals by equalising the sexes. After due consideration of the whole

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of defective measurements. (ii) We tabled Parsons' measurements which are not of the bicondylar width but of the width of the lower articulation. The following tables resulted:

Width of Lower Articulation. Parsons' Data.

Right Side.

	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	Totals
♂	—	—	—	—	—	—	—	—	1	2	2	1	2	2	5	12	9	9	8	3	1	4	1	4	—	—	—	2	68
♀	—	—	—	2	4	3	4	8	6	4	4	4	3	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	43
Totals	—	—	—	2	4	3	4	8	7	6	6	5	5	2	6	12	9	9	8	3	1	4	1	4	—	—	—	2	111

Left Side.

♂	—	—	—	—	—	1	—	—	—	1	—	4	6	4	2	12	10	12	9	11	4	3	12	—	1	—	—	—	92
♀	1	—	—	3	2	5	2	9	7	9	4	2	—	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	46
Totals	1	—	—	3	2	6	2	9	7	10	4	6	6	5	2	13	10	12	9	11	4	3	12	—	1	—	—	—	138

These give for R., $r = \cdot 9979$ and for L., $r = 1 \cdot 0473$—numbers agreeing closely with ours, but with the anomalous value transferred now to the left side. (iii) To smooth out random irregularities we worked the table for observed sex-totals for R. bones in 2 mm. ranges instead of 1 mm. ranges. We found $r = 1 \cdot 0276$. (iv) In order to increase our material we pooled right and left bones for observed sex-totals in 2 mm. ranges and reached $r = 1 \cdot 0007$. (v) We slightly increased the sex proportions to represent more closely the actual number of *adult* females dying to adult males, say 51 to 49; r came out now 1·0068, or small changes of this kind are of no importance. (vi) We developed from the equation to the normal surface a formula for determining biserial r from the standard deviations of the two arrays; it is:

$$r^2 = \frac{\frac{n_f n_m}{N^2}\left\{\sigma_f^2 - \sigma_m^2 + \frac{n_m - n_f}{N}(m_m - m_f)^2\right\}}{z_h h\left\{\frac{n_m \sigma_m^2 + n_f \sigma_f^2}{N} + \frac{n_m n_f}{N^2}(m_m - m_f)^2\right\}},$$

where $z_h = \frac{1}{\sqrt{2\pi}} e^{-\frac{1}{2}h^2}$ and h is to be found from $\frac{n_f}{N} = \frac{1}{\sqrt{2\pi}} \int_h^\infty e^{-\frac{1}{2}x^2} dx$. Worked out by this control formula we find for bicondylar width of R. bones: Biserial $r = \cdot 9931$. This is, of course, for observed sex totals. We have, however, no right to replace the value found for observed sex totals, *i.e.* 1·0269 from the usual formula:

$$r = \frac{m - m_f}{\sigma z_k / (n_f / N)}$$

$$= \frac{\frac{n_f n_m}{N^2}(m_m - m_f)}{z_k \times \sqrt{\frac{n_m \sigma_m^2 + n_f \sigma_f^2}{N} + \frac{n_m n_f}{N^2}(m_m - m_f)^2}},$$

by this new value simply *because the latter is less than unity.* Our new control formula does, however, indicate that if the correlation be worked on the standard deviations instead of the means of the arrays,

matter we determined to adopt the figures in the fifth column of the second table on p. 149 as representing with sufficient accuracy the relation between appreciation of sex and our four sexually differentiated characters. In doing this we were guided by the fact that there is no very great divergence between the results for right and left bones nor between the results for equalised and observed sex totals, while as shown in the footnote a selection of 30°/₀ made no substantial difference in the value of the correlation.

In the next place we determined the values of the correlations of the four characters with each other. The values were as follows:

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we should get a possible value of biserial r, and that comfortably close to the value given in the fifth column of figures in the second table on p. 149. (vii) There is, however, another aspect of the matter which indicates the probable source of the difficulty, *i.e.* the great difference in the standard deviations of ♂ and ♀ bicondylar widths. This suggests (as the totals observed for the sexes also do) far more stringent selection of the female bones. (It is of course possible that in time of plague many more men would die than women as the latter would have been sent out of London in larger numbers.) We accordingly made the hypothesis that selection of the femora takes place according to size increasing uniformly from *all* at the arbitrary value of 40 mm. to zero at the arbitrary value of 80 mm. In other words: Observed Frequency = Actual Frequency $\left(1-\frac{1}{p}\right)$, where $\frac{1}{p}=2-\frac{x}{40}$, x being the bicondylar width in mm. Thus we have

$$\text{Actual Frequency} = \text{Observed Frequency} \Big/ \left(\frac{x}{40}-1\right).$$

Reconstructing roughly by this formula we find for our unselected distribution:

Bicondylar Width, Right Side, Reconstructed Material.

	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	Totals
♂	—	—	—	—	—	—	—	—	—	1	3	1	2	7	11	12	12	20	10	16	15	18	9	11	10	8	4	2	2	174
♀	1	1	3	7	10	9	9	14	15	9	17	23	5	5	6	3	2	—	—	—	—	—	—	—	—	—	—	—	—	139
Totals	1	1	3	7	10	9	9	14	15	10	20	24	7	12	17	15	14	20	10	16	15	18	9	11	10	8	4	2	2	313

It is clear that the suggested selection has not been sufficiently stringent to equalise the sexes, but it will suffice to show whether it is in the right direction for explaining the anomaly. This table leads to: $m_m = 79{\cdot}704$, $m_f = 69{\cdot}703$, $\sigma_m = 3{\cdot}993$, $\sigma_f = 3{\cdot}421$; thus providing very little change in the variations and only about ·5 mm. in the mean bicondylar widths. It follows that considerable selective action could exist without materially changing means or variations. We deduce for equal sex-totals $r = 1{\cdot}0057$, and for the above modified sex-totals 1·0040. Both values are lower but still above unity. Accordingly selective action is in the right direction, but it would have to be considerably more intense than we have assumed it to be in order to bring biserial r below unity.

As we cannot be certain how far the result is due to selective action, and how far to non-normal distribution we have not pursued the matter further. We think it not unreasonable, however, to assume that the correlation of bicondylar width with appreciation of sex cannot differ much from the value given at the top of the fifth column of figures in the second table on p. 149, *i.e.* may be taken as ·9929.

Correlation of chief Sexually Differentiated Femoral Characters.

Character Pair	Male			Female		
	R.	L.	Mean of R.+L.	R.	L.	Mean of R.+L.
Bicondylar Width and Vert. Diam. of Head	·7496 ± ·0244	·7702 ± ·0227	·7599	·5843 ± ·0476	·6536 ± ·0379	·6190
Bicondylar Width and Vert. Diam. of Neck	·6828 ± ·0290	·6919 ± ·0279	·6873	·2974 ± ·0624	·3878 ± ·0541	·3426
Bicondylar Width and Ext. Condyle, Oblique Length	·7602 ± ·0232	·7536 ± ·0235	·7569	·6056 ± ·0440	·5551 ± ·0451	·5803
Vert. Diam. of Head and Vert. Diam. of Neck	·7580 ± ·0201	·7717 ± ·0189	·7310	·6120 ± ·0350	·6563 ± ·0298	·6342
Vert. Diam. of Head and Ext. Condyle, Oblique Length	·7067 ± ·0249	·6419 ± ·0295	·6743	·5574 ± ·0418	·4877 ± ·0446	·5225
Vert. Diam. of Neck and Ext. Condyle, Oblique Length	·5273 ± ·0347	·5395 ± ·0338	·5334	·3669 ± ·0500	·2751 ± ·0507	·3210

These are, however not the correlations we require to obtain a maximum sex discriminant. We need the correlations for *combined* sexes. These can be found from the formula[1]

$$r = \frac{\frac{n_f}{N} r_f \sigma_f \sigma_f' + \frac{n_m}{N} r_m \sigma_m \sigma_m' + \frac{n_f n_m}{N^2} (m_m - m_f)(m_m' - m_f')}{\sqrt{\frac{n_f}{N}\sigma_f^2 + \frac{n_m}{N}\sigma_m^2 + \frac{n_f n_m}{N^2}(m_m - m_f)^2}\sqrt{\frac{n_f}{N}\sigma_f'^2 + \frac{n_m}{N}\sigma_m'^2 + \frac{n_f n_m}{N^2}(m_m' - m_f')^2}},$$

where m, f, subscripts denote male and female and dashed and undashed letters refer to the two characters correlated.

From the above formula we deduce:

Table of combined Sex Correlations for Chief Sexually Differentiated Femoral Characters.

Character Pair	R.	L.	Mean of R.+L.
Bicondylar Width and Vert. Diameter of Head	·8897	·8924	·8910
Bicondylar Width and Vert. Diameter of Neck	·8030	·8228	·8129
Bicondylar Width and Oblique Length, External Condyle	·8843	·8604	·8723
Vert. Diameter of Head and Vert. Diameter of Neck	·8587	·8746	·8666
Vert. Diameter of Head and Oblique Length, External Condyle ...	·8490	·8119	·8305
Vert. Diameter of Neck and Oblique Length, External Condyle ...	·7337	·7247	·7292

It is clear from these results that: (i) the differences of right and left bones' correlations are very small and of the order of the probable errors; it will be

[1] Pearson, *Phil. Trans.* Vol. 192, A., p. 277.

sufficient therefore to use for the correlations the mean of R. and L. values throughout; (ii) the correlations are all high and we shall accordingly gain somewhat but not very substantially by forming our appreciation of sex on the four instead of on any one of the chief sexually differentiated femoral characters. We have, accordingly, proceeded to the determination of the linear function of the four characters which exhibits the maximum correlation with sex-appreciation. We take the subscripts 0 to stand for sex, 1 for bicondylar width, 2 for vertical diameter of head, 3 for oblique length of external condyle, and 4 for the vertical diameter of neck.

Our system of correlations will be:

$$r_{01} = \cdot 9929, \quad r_{12} = \cdot 8910, \quad r_{23} = \cdot 8305,$$
$$r_{02} = \cdot 9615, \quad r_{13} = \cdot 8723, \quad r_{24} = \cdot 8666,$$
$$r_{03} = \cdot 9052, \quad r_{14} = \cdot 8129, \quad r_{34} = \cdot 7292,$$
$$r_{04} = \cdot 8683.$$

Our multiple regression equation is:

$$\frac{\tilde{x}_0 - \bar{x}_0}{\sigma_0} = b_1 \frac{x_1 - \bar{x}_1}{\sigma_1} + b_2 \frac{x_2 - \bar{x}_2}{\sigma_2} + b_3 \frac{x_3 - \bar{x}_3}{\sigma_3} + b_4 \frac{x_4 - \bar{x}_4}{\sigma_4},$$

where the b's are to be determined by:

$$\cdot 9929 = b_1 + \cdot 8910 b_2 + \cdot 8723 b_3 + \cdot 8129 b_4,$$
$$\cdot 9615 = \cdot 8910 b_1 + b_2 + \cdot 8305 b_3 + \cdot 8666 b_4,$$
$$\cdot 9052 = \cdot 8723 b_1 + \cdot 8305 b_2 + b_3 + \cdot 7292 b_4,$$
$$\cdot 8683 = \cdot 8129 b_1 + \cdot 8666 b_2 + \cdot 7292 b_3 + b_4.$$

These give:

$$b_1 = \cdot 5962, \quad b_2 = \cdot 3224, \quad b_3 = \cdot 0883, \quad b_4 = \cdot 0399.$$

It will be seen at once from these values how much more important is the bicondylar width than the vertical diameter of the head, and how both of them are of far more significance than the oblique length of the external condyle or the vertical diameter of the neck.

Probably the formula:

$$\frac{\tilde{x}_0 - \bar{x}_0}{\sigma_0} = \cdot 5962 \frac{x_1 - \bar{x}_1}{\sigma_1} + \cdot 3224 + \frac{x_2 - \bar{x}_2}{\sigma_2} + \cdot 0883 \frac{x_3 - \bar{x}_3}{\sigma_3} + \cdot 0399 \frac{x_4 - \bar{x}_4}{\sigma_4} \quad \ldots\ldots (\mathrm{E})$$

would apply practically to the sexing of the femora of any race, if the values of the means $\bar{x}_1$, $\bar{x}_2$, $\bar{x}_3$, $\bar{x}_4$, and the standard deviations σ_1, σ_2, σ_3, σ_4 for that race were substituted. These are the means and standard deviations of the characters without regard to *sex*. We should probably, however, get slightly better results by substituting separately for right and left bones. We accordingly substitute these values for our English femora, where we have from the biserial tables:

	R.	L.		R.	L.
$\bar{x}_1$	76·5709	75·6607	σ_1	6·1747	6·0375
$\bar{x}_2$	44·5824	44·0992	σ_2	3·8923	3·8148
$\bar{x}_3$	59·1370	58·3719	σ_3	4·1620	4·0443
$\bar{x}_4$	31·9635	32·1525	σ_4	3·2759	3·3269

Hence we find: for R. side,—

$$\frac{\tilde{x}_0 - \bar{x}_0}{\sigma_0} = \cdot 09656x_1 + \cdot 08283x_2 + \cdot 02121x_3 + \cdot 01218x_4 - 12\cdot 73007,$$

and for L. side,—

$$\frac{\tilde{x}_0 - \bar{x}_0}{\sigma_0} = \cdot 09875x_1 + \cdot 08451x_2 + \cdot 02183x_3 + \cdot 01199x_4 - 12\cdot 85808.$$

But we have about 202 ♂ to 141 ♀ right bones, or the value of the dividing line between judgment as male and as female is $(\tilde{x}_0 - \bar{x}_0)/\sigma_0 = -\cdot 22477$[1]. Further we have about 205 ♂ to 155 ♀ left bones, or the value of the dividing line between judgment as male and as female is in this case $(\tilde{x}_0 - \bar{x}_0)/\sigma = -\cdot 17496$. We can accordingly sum up our anatomical results in the following manner:

A right bone will be appreciated as male or female according as:

$\cdot 09656x_1 + \cdot 08283x_2 + \cdot 02121x_3 + \cdot 01218x_4$ is $>$ or $<$ $12\cdot 50530$.

A left bone will be appreciated as male or female according as:

$\cdot 09875x_1 + \cdot 08451x_2 + \cdot 02183x_3 + \cdot 01199x_4$ is $>$ or $<$ $12\cdot 68312$.

We can put these into the forms:

For right bone:

$$\cdot 7722x_1 + \cdot 6624x_2 + \cdot 1696x_3 + \cdot 0974x_4 > \text{ or } < 100.$$

For left bone:

$$\cdot 7786x_1 + \cdot 6663x_2 + \cdot 1721x_3 + \cdot 0945x_4 > \text{ or } < 100.$$

These results differ so slightly that it is probably just as accurate to use the mean of them for either bone. Accordingly we conclude that if the measurements be taken in millimetres a bone will be appreciated as male or female according as: (·7754 × Bicondylar Width + ·6643 × Vertical Diameter of Head + ·1709 × Oblique Length of External Condyle + ·0960 × Minimum Vertical Diameter of the Neck) is or is not greater than 100. This result is only deduced for our seventeenth century London bones, but it is not improbable that it has a wider application, and, if not, a more suitable formula can be deduced by substituting in Equation (E) on p. 153 the observed values for the mean and standard deviations of any other unsexed material. Of course when the above expression approaches closely to 100 the sex will be doubtful. To appreciate what we must not consider "close" we note that the value of the expression for the typical male femur is 107·23 and for the typical female femur is 94·05[2].

The data below illustrate the result of sexing by the above inequality.

[1] The negative sign must be given because the origin of sex appreciation is on the male side of the sex division.

[2] It is desirable to impress upon the reader that the above formula does not *fix* the sex. By its deviation from 100, it measures the most probable or *mean* sex appreciation of all femora having the given characters, but unless the deviation from 100 is very considerable some of these femora will be males and some females, according to the anatomical appreciation. It would seem desirable accordingly to label femora from 96 to 100 as ♀? and 100 to 104 as ♂?, or possibly even to regard 99 to 101 as merely ♂.

Starting with W. 73 we took the 32 male femora which followed and had the four characters given, using if needful queried values. Starting with W. 24 we took the 32 female crania which followed under the same conditions[1].

Sex Value	Anat.	Sex Value	Anat.	Sex Value	Anat.	Sex Value	Anat.
113·1 ♂	♂	104·8 ♂	♂	98·7 ?♀	♀	94·0 ♀	♀
112·4 ♂	♂	104·1 ♂	♂	97·9 ?♀	♂?	93·7 ♀	♀
111·3 ♂	♂	103·7 ?♂	♂	97·4 ?♀	♂?	93·6 ♀	♀?
109·3 ♂	♂	103·4 ?♂	♂	96·7 ?♀	♀?	93·1 ♀	♀
109·1 ♂	♂	103·2 ?♂	♀	96·4 ?♀	♀	92·9 ♀	♀
107·9 ♂	♂	103·1 ?♂	♀	96·2 ?♀	♂?	92·9 ♀	♀
107·8 ♂	♂	103·0 ?♂	♂	96·0 ?♀	♀	91·8 ♀	♀
107·4 ♂	♂	102·8 ?♂	♂	95·7 ♀	♀	91·0 ♀	♀
107·4 ♂	♂	102·1 ?♂	♂	95·6 ♀	♀	90·5 ♀	♀
106·9 ♂	♂	101·6 ?♂	♂	95·6 ♀	♀	90·2 ♀	♀
105·9 ♂	♂	101·4 ?♂	♂?	95·0 ♀	♀?	89·0 ♀	♀
105·6 ♂	♂	101·3 ?♂	♀	94·9 ♀	♀	88·9 ♀	♀
105·6 ♂	♂	100·9 ♁	♂	94·8 ♀	♀	88·8 ♀	♀?
105·4 ♂	♂	99·4 ♁	♂	94·7 ♀	♂?	87·9 ♀	♀
105·3 ♂	♂	99·3 ♁	♀	94·6 ♀	♀	84·0 ♀	♀
105·1 ♂	♂	98·9 ?♀	♂?	94·2 ♀	♀	82·9 ♀	♀

It will be observed that all the femora called definitely ♂ by the sex-value method are termed male by the anatomist; that all the 25 femora given as definitely female by the sex-value method are termed definitely female by the anatomist except three, one of which is given as doubtfully male and shows signs of syphilis and two as doubtfully female. Of the three individuals marked as ♁ by the sex-value method, the first, just over 100, is given as male by the anatomist and the two just under 100 as one male and one female. Of the 10 marked as ♂? by the sex-value method, six are given as definitely ♂, there is one ♂? and three are called female by the anatomist. Of the 8 femora recorded as ♀? by the sex-value method three are given as female and one as ♀? by the anatomist and four as ♂?. Thus the sex-value method, which may be taken to represent a smoothing or graduation of anatomical opinion, gives results in very reasonable accordance with anatomical opinion of the sex of individual bones. It could not have been obtained without a previous anatomical judgment of a long series, but having been obtained is probably of more value than the individual anatomical judgments in each discordant instance.

If we put aside general appreciation of sex from muscularity—possibly no very certain guide if the graves investigated contain a mixture of classes—then many anatomists probably judge largely by apparent size of epiphyses. It may be questioned whether the absolute measurements of the epiphysial characters and the use of a formula like that just given may not be more effective. It is further possible that such a formula might be of service in certain cases of medical jurisprudence. The tables on which the above investigations are based will be found on the following pages.

[1] If it were desired to sex a bone in which one or more of the required characters failed it would be needful to work out the two and three variable regression equations for the known variables.

I. *Biserial Tables.*

TABLE 1 *A*. *Bicondylar Width, R. Bones.*

	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	Totals
♂	—	—	—	—	—	—	—	—	—	—	2	1	2	6	10	11	11	19	10	16	15	18	9	11	10	8	4	2	2	167
♀	—	—	2	4	6	6	6	10	11	7	13	18	4	4	5	3	2	—	—	—	—	—	—	—	—	—	—	—	—	101
Totals	—	—	2	4	6	6	6	10	11	7	15	19	6	10	15	14	13	19	10	16	15	18	9	11	10	8	4	2	2	268

61 signifies the group 59·75—61·75

TABLE 1 *B*. *Bicondylar Width, L. Bones.*

♂	—	—	—	—	—	—	—	—	—	3	—	3	6	7	18	8	15	13	11	16	13	14	9	6	11	7	3	—	2	165
♀	1	1	—	2	7	8	10	11	18	11	9	12	9	7	4	3	—	—	1	1	—	—	—	—	—	—	—	—	—	115
Totals	1	1	—	2	7	8	10	11	18	14	9	15	15	14	22	11	15	13	12	17	13	14	9	6	11	7	3	—	2	280

TABLE 2 *A*. *Vertical Diameter of Head, R. Bones.*

	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	Totals
♂	—	—	—	—	2	3	5	16	19	21	31	28	23	21	18	10	6	4	—	1	208
♀	1	5	8	30	26	25	26	16	6	4	1	1	1	—	—	—	—	—	—	—	150
Totals	1	5	8	30	28	28	31	32	25	25	32	29	24	21	18	10	6	4	—	1	358

36 signifies the group 35·75—36·75

TABLE 2 *B*. *Vertical Diameter of Head, L. Bones.*

♂	—	—	1	—	1	6	8	14	24	23	32	34	13	28	8	13	4	1	—	1	211
♀	5	8	14	21	30	29	35	14	6	5	—	—	—	—	—	—	—	—	—	—	167
Totals	5	8	15	21	31	35	43	28	30	28	32	34	13	28	8	13	4	1	—	1	378

TABLE 3 *A*. *Oblique Length External Condyle, R. Bones.*

	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	Totals
♂	—	—	—	—	—	1	—	5	7	10	14	17	25	27	31	18	17	13	12	6	2	2	207
♀	—	—	4	10	7	15	17	23	28	13	13	8	3	3	2	1	—	—	—	—	—	—	147
Totals	—	—	4	10	7	16	17	28	35	23	27	25	28	30	33	19	17	13	12	6	2	2	354

48 signifies the group 47·75—48·75

TABLE 3 *B*. *Oblique Length External Condyle, L. Bones.*

♂	—	—	—	1	—	1	4	4	11	19	13	21	21	35	16	26	13	12	9	2	1	—	209
♀	2	—	2	5	15	18	36	25	17	13	8	7	1	3	—	—	—	—	—	—	—	—	152
Totals	2	—	2	6	15	19	40	29	28	32	21	28	22	38	16	26	13	12	9	2	1	—	361

TABLE 4 *A*. *Minimum Vertical Diameter of the Neck, R. Bones.*

	24	24·5	25	25·5	26	26·5	27	27·5	28	28·5	29	29·5	30	30·5	31	31·5	32	32·5	33	33·5	34	34·5	35	35·5	36	36·5	37	37·5	38	38·5	39	39·5	40	40·5	41	41·5	Totals
♂	—	—	—	—	—	—	—	1	2	2	5	3	8	5	16	12	22	14	14	20	14	14	18	10	8	8	6	5	5	5	—	2	2	1	1	2	225
♀	1	—	—	2	5	9	9	10	23	16	11	15	21	11	8	8	4	6	—	3	—	—	—	1	—	—	—	1	—	—	—	—	—	—	—	—	164
Totals	1	—	—	2	5	9	9	11	25	18	16	18	29	16	24	20	26	20	14	23	14	14	18	11	8	8	6	6	5	5	—	2	2	1	1	2	389

TABLE 4 *B*. *Minimum Vertical Diameter of the Neck, L. Bones.*

	22	22·5	23	23·5	24	24·5	25	25·5	26	26·5	27	27·5	28	28·5	29	29·5	30	30·5	31	31·5	32	32·5	33	33·5	34	34·5	35	35·5	36	36·5	37	37·5	38	38·5	39	39·5	40	40·5	41	Totals
♂	—	—	—	—	—	—	—	—	—	1	—	2	—	2	5	1	5	7	10	13	18	13	10	21	20	15	15	18	10	8	12	8	10	2	4	2	2	—	1	235
♀	1	—	—	—	—	3	1	—	5	6	10	12	12	17	25	17	23	11	14	9	8	5	2	1	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	186
Totals	1	—	—	—	—	3	1	—	5	7	10	14	12	19	30	18	28	18	24	22	26	18	12	22	24	15	15	18	10	8	12	8	10	2	4	2	2	—	1	421

24 signifies the group 21·95—22·45

II. *Product Moment Tables.*

TABLE 5 *A.* *Vertical Diameter of Head, ♂ R. Bones.*

Bicondylar Width mm.	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	Totals
70	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
71	–	1	–	1	–	–	–	–	–	–	–	–	–	–	–	–	2
72	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
73	–	1	–	1	–	–	–	–	–	–	–	–	–	–	–	–	2
74	1	–	2	1	–	1	–	–	–	–	–	–	–	–	–	–	5
75	–	–	–	2	2	–	6	–	–	–	–	–	–	–	–	–	10
76	–	–	–	–	1	6	2	1	–	–	–	–	–	–	–	–	10
77	–	–	–	2	1	3	3	1	–	–	–	1	–	–	–	–	11
78	–	–	1	1	4	1	2	1	2	1	4	–	–	–	–	–	17
79	–	–	–	–	3	2	2	1	1	–	–	–	–	–	–	–	9
80	–	–	–	–	2	2	2	6	2	1	–	–	–	–	–	–	15
81	–	–	–	–	–	–	3	3	5	3	1	–	–	–	–	–	15
82	–	–	–	–	–	1	1	1	1	2	–	1	–	1	–	–	8
83	–	–	–	–	–	–	–	1	1	3	2	–	1	–	–	–	8
84	–	–	–	–	–	1	1	1	3	1	3	1	–	–	–	–	11
85	–	–	–	–	–	–	1	–	–	3	1	1	1	1	–	1	9
86	–	–	–	–	–	–	–	–	2	1	2	1	–	–	–	–	6
87	–	–	–	–	–	–	–	–	–	–	1	1	–	1	–	–	3
88	–	–	–	–	–	–	–	–	–	1	–	–	1	–	–	–	2
89	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	2
Totals	1	3	3	8	13	17	23	16	17	16	14	6	5	3	–	1	146

TABLE 5 *B.* *Vertical Diameter of Head, ♂ L. Bones.*

Bicondylar Width mm.	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	Totals
70	–	–	1	1	–	–	1	–	–	–	–	–	–	–	–	–	3
71	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
72	1	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	3
73	–	–	1	2	2	1	–	–	–	–	–	–	–	–	–	–	6
74	–	–	1	2	1	2	–	1	–	–	–	–	–	–	–	–	7
75	–	–	–	4	3	6	1	3	1	–	–	–	–	–	–	–	18
76	–	1	1	–	5	–	–	1	–	–	–	–	–	–	–	–	8
77	–	1	–	1	2	1	3	3	1	–	–	–	–	–	–	–	12
78	–	–	–	–	4	1	5	–	2	1	–	–	–	–	–	–	13
79	–	–	–	1	2	4	1	2	1	–	–	–	–	–	–	–	11
80	–	–	–	–	2	–	3	2	2	3	1	2	–	–	–	–	15
81	–	–	–	–	–	–	–	1	3	–	2	1	1	–	–	–	8
82	–	–	–	–	–	–	1	2	2	2	3	1	–	1	–	–	12
83	–	–	–	–	–	1	1	3	2	2	–	–	–	–	–	–	9
84	–	–	–	–	–	–	–	1	–	1	–	2	–	–	–	–	4
85	–	–	–	–	–	–	–	1	–	3	1	4	–	–	–	–	9
86	–	–	–	–	–	–	–	–	1	1	1	1	1	–	–	–	5
87	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	1
88	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
89	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	1	2
Totals	1	3	5	11	21	16	17	22	12	16	7	11	2	1	–	1	146

TABLE 5 *C.* *Vertical Diameter of Head, ♀ R. Bones.*

Bicondylar Width mm.	36	37	38	39	40	41	42	43	44	45	46	47	48	Totals
61	–	–	–	–	–	–	–	–	–	–	–	–	–	–
62	–	–	–	–	–	–	–	–	–	–	–	–	–	–
63	–	1	–	1	–	–	–	–	–	–	–	–	–	2
64	1	1	–	1	1	–	–	–	–	–	–	–	–	4
65	–	–	–	2	2	1	1	–	–	–	–	–	–	6
66	–	–	–	2	2	1	–	–	–	–	–	–	–	5
67	–	–	3	–	3	–	–	–	–	–	–	–	–	6
68	–	–	–	1	5	1	1	1	–	–	–	–	–	9
69	–	1	–	4	1	1	1	–	1	–	–	–	–	9
70	–	–	–	3	1	2	1	–	–	–	–	–	–	7
71	–	–	2	1	2	–	3	–	1	–	–	–	–	9
72	–	–	–	4	3	5	3	–	–	–	–	–	–	15
73	–	–	–	–	–	1	1	–	1	–	–	–	–	3
74	–	–	–	–	1	1	1	–	–	1	–	–	–	4
75	–	–	–	–	–	–	1	3	–	–	–	–	–	4
76	–	–	–	–	–	–	1	1	–	–	–	–	–	2
77	–	–	–	–	–	–	–	1	–	1	–	–	–	2
78	–	–	–	–	–	–	–	–	–	–	–	–	–	–
79	–	–	–	–	–	–	–	–	–	–	–	–	–	–
80	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Totals	1	3	5	19	21	13	14	6	3	2	–	–	–	87

TABLE 5 *D.* *Vertical Diameter of Head, ♀ L. Bones.*

Bicondylar Width mm.	36	37	38	39	40	41	42	43	44	45	Totals
61	1	–	–	–	–	–	–	–	–	–	1
62	–	1	–	–	–	–	–	–	–	–	1
63	–	–	–	–	–	–	–	–	–	–	–
64	–	1	–	–	1	–	–	–	–	–	2
65	1	–	1	3	2	–	–	–	–	–	7
66	–	2	4	1	1	–	–	–	–	–	8
67	–	–	1	2	4	2	1	–	–	–	10
68	1	–	2	2	3	2	1	–	–	–	11
69	–	–	–	4	4	3	6	–	–	–	17
70	–	–	–	1	1	4	1	1	–	–	8
71	–	–	–	–	1	3	3	–	–	–	7
72	–	–	1	–	1	3	5	–	1	–	11
73	–	–	–	–	3	1	1	2	–	–	7
74	–	–	1	1	1	–	1	1	1	–	6
75	–	–	–	–	–	–	2	1	–	1	4
76	–	–	–	–	1	–	–	1	–	–	2
77	–	–	–	–	–	–	–	–	–	–	–
78	–	–	–	–	–	–	–	–	–	–	–
79	–	–	–	–	–	–	–	–	–	1	1
80	–	–	–	–	–	–	–	1	–	–	1
Totals	3	4	10	15	22	18	22	6	2	2	104

TABLE 6 *A.*

Minimum Vertical Diameter of Neck mm.	2	3	5	16	19	21	30	28	22	20	18	10	6	4	–	1	Totals
26	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
27	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	1
28	–	1	1	–	1	–	–	–	–	–	–	–	–	–	–	–	3
29	1	1	–	–	2	3	1	–	–	–	–	–	–	–	–	–	8
30	1	–	2	2	2	2	3	–	–	–	–	–	–	–	–	–	12
31	–	1	1	6	6	4	5	4	–	–	–	–	–	–	–	–	27
32	–	–	1	4	5	6	7	2	3	1	–	–	–	–	–	–	29
33	–	–	–	1	3	–	8	9	6	5	2	–	–	–	–	–	34
34	–	–	–	2	–	3	3	8	5	1	3	1	–	–	–	–	26
35	–	–	–	–	–	1	2	2	5	8	3	1	1	1	1	1	25
36	–	–	–	–	–	1	–	1	1	5	5	1	1	–	–	–	15
37	–	–	–	–	–	1	1	2	–	–	4	2	1	1	–	–	12
38	–	–	–	–	–	–	–	–	2	–	1	3	2	1	–	–	9
39	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	1
40	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	1
41	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	2
Totals	2	3	5	16	19	21	30	28	22	20	18	10	6	4	–	1	205

TABLE 6 *B.*

Minimum Vertical Diameter of Neck mm.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	Totals
22	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
23	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
24	–	1	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
25	–	2	–	2	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5
26	–	–	3	1	3	4	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	12
27	–	1	3	4	4	3	3	3	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	22
28	–	2	2	4	7	6	7	1	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	31
29	–	–	1	1	4	5	7	4	2	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	24
30	–	–	–	2	2	2	5	9	5	7	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	31
31	–	–	–	–	1	2	2	5	9	2	5	1	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	28
32	–	–	–	–	1	–	1	1	5	5	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	17
33	–	–	–	–	–	1	–	1	2	1	–	7	1	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	15
34	–	–	–	–	–	–	–	–	–	2	1	2	2	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10
35	–	–	–	–	–	–	–	–	–	–	2	–	–	1	2	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	6
36	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
37	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Totals	1	6	8	14	24	22	32	33	14	27	8	13	4	1	–	1	208																										

TABLE 6 *C.*

Minimum Vertical Diameter of Neck mm.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	Totals
22	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
23	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
24	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
25	–	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
26	1	2	1	4	2	2	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	13
27	–	2	3	7	3	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	17
28	–	1	2	11	6	9	2	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	32
29	–	–	1	2	8	5	5	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	22
30	–	–	–	3	3	4	15	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	30
31	–	–	–	1	1	3	1	4	2	1	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	15
32	–	–	–	–	1	–	–	5	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	8
33	–	–	–	–	–	–	–	–	–	1	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3
34	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
35	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
36	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
37	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Totals	1	5	8	30	25	25	24	15	6	4	–	1	1																														

TABLE 6 *D.*

Minimum Vertical Diameter of Neck mm.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	Totals
22	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
23	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
24	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3
25	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
26	1	3	4	1	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	11
27	2	2	2	3	5	5	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	22
28	–	2	4	9	4	3	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	24
29	–	–	4	5	11	8	9	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	38
30	–	–	–	1	6	7	13	3	2	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	33
31	–	–	–	2	1	3	3	6	1	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	18
32	–	–	–	–	–	2	3	3	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10
33	–	–	–	–	–	–	1	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
34	–	–	–	–	–	–	1	1	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3
35	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
36	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
37	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Totals	3	8	14	21	30	28	35	14	6	5																																166

II. *Product Moment Tables* (cont.).

Table 7 *A*. *Oblique Length, External Condyle, ♂ R. Bones.*

Bicondylar Width mm.	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	Totals
70	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
71	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	1
72	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	1
73	–	–	–	1	–	–	–	–	1	–	–	–	–	–	–	–	–	2
74	–	–	1	2	–	1	2	–	–	–	–	–	–	–	–	–	–	6
75	–	–	1	–	1	2	3	1	–	1	–	1	–	–	–	–	–	10
76	–	–	–	–	1	3	1	2	2	2	–	–	–	–	–	–	–	11
77	–	–	–	1	–	3	2	2	1	1	–	–	–	–	–	–	–	10
78	1	–	–	–	2	2	1	2	4	5	1	1	–	–	–	–	–	19
79	–	–	–	–	–	–	–	2	4	3	–	–	–	–	–	–	–	9
80	–	–	–	–	1	1	2	6	1	1	1	2	–	–	1	–	–	16
81	–	–	–	–	–	–	–	3	2	3	4	2	–	1	–	–	–	15
82	–	–	–	–	–	–	1	–	1	4	1	1	–	–	–	–	–	8
83	–	–	–	–	–	–	1	–	–	2	1	1	3	1	–	–	–	9
84	–	–	–	–	–	–	–	–	–	–	2	2	3	1	–	–	–	8
85	–	–	–	–	–	–	–	–	–	1	3	1	1	2	2	–	–	10
86	–	–	–	–	–	–	–	–	–	–	–	–	4	2	–	1	1	8
87	–	–	–	–	–	–	–	–	–	–	–	1	–	1	2	–	–	4
88	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	2
89	–	–	–	–	–	–	–	–	1	–	–	–	1	–	–	–	–	2
Totals	1	–	2	4	7	12	13	18	17	23	13	12	12	10	5	1	1	151

Table 7 *B*. *Oblique Length, External Condyle, ♂ L. Bones.*

mm.	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	Totals
70	–	–	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	2
71	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
72	–	–	–	–	–	1	1	1	–	–	–	–	–	–	–	–	–	–	3
73	–	–	–	1	1	–	–	1	1	1	1	–	–	–	–	–	–	–	6
74	–	–	–	–	–	–	3	1	1	–	–	–	–	–	–	–	–	–	5
75	1	–	–	–	–	–	6	4	2	1	2	–	–	–	–	–	–	–	16
76	–	–	–	1	–	1	1	–	1	2	1	1	–	–	–	–	–	–	8
77	–	–	–	1	–	2	2	–	3	2	3	–	–	1	–	–	–	–	14
78	–	–	–	–	–	1	2	1	2	2	2	1	1	–	–	–	–	–	12
79	–	–	–	–	–	1	–	1	4	3	2	–	–	–	–	–	–	–	11
80	–	–	–	–	–	2	–	1	1	–	5	–	5	–	–	2	–	–	16
81	–	–	–	–	–	–	–	–	–	4	1	3	2	2	1	–	–	–	13
82	–	–	–	–	–	1	–	–	–	2	2	3	2	3	1	–	–	–	14
83	–	–	–	–	–	–	–	–	–	–	3	–	3	1	–	–	1	–	8
84	–	–	–	–	–	–	–	–	–	–	1	1	1	–	2	–	–	–	5
85	–	–	–	–	–	–	–	–	–	–	1	1	3	1	3	2	–	–	11
86	–	–	–	–	–	–	–	–	–	–	–	–	1	–	2	1	–	1	5
87	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1	–	1	–	3
88	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
89	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1	–	–	2
Totals	1	–	–	4	2	9	15	10	15	17	24	10	18	9	11	6	2	1	154

Table 7 *C*. *Oblique Length, External Condyle, ♀ R. Bones.*

mm.	50	51	52	53	54	55	56	57	58	59	60	61	62	Totals
61	–	–	–	–	–	–	–	–	–	–	–	–	–	–
62	–	–	–	–	–	–	–	–	–	–	–	–	–	–
63	–	–	1	–	1	–	–	–	–	–	–	–	–	2
64	–	1	–	2	–	–	1	–	–	–	–	–	–	4
65	–	1	1	2	–	1	–	–	–	–	–	–	–	5
66	–	1	–	1	1	2	–	–	1	–	–	–	–	6
67	–	2	1	1	1	–	–	–	–	–	–	–	–	5
68	–	1	2	1	2	2	1	–	1	–	–	–	–	10
69	1	–	–	3	–	2	2	1	–	–	–	–	–	9
70	1	–	–	–	–	4	1	–	1	–	–	–	–	7
71	–	–	–	2	1	5	2	–	3	–	–	–	–	13
72	–	–	–	1	2	3	7	1	2	2	–	–	–	18
73	–	–	–	–	–	–	–	–	1	1	1	–	–	3
74	–	–	–	–	–	1	1	1	–	–	–	–	–	3
75	–	–	–	–	1	–	1	2	–	–	–	–	–	4
76	–	–	–	–	–	–	1	1	–	1	–	1	–	3
77	–	–	–	–	–	–	–	–	–	1	–	1	–	2
78	–	–	–	–	–	–	–	–	–	–	–	–	–	–
79	–	–	–	–	–	–	–	–	–	–	–	–	–	–
80	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Totals	2	6	5	13	9	20	17	6	9	5	1	1	–	94

Table 7 *D*. *Oblique Length, External Condyle, ♀ L. Bones.*

mm.	48	49	50	51	52	53	54	55	56	57	58	59	60	61	Totals
61	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1
62	–	–	1	–	–	–	–	–	–	–	–	–	–	–	1
63	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
64	–	–	–	–	–	1	–	–	1	–	–	–	–	–	2
65	–	–	1	–	2	1	–	–	–	1	–	–	–	–	5
66	–	–	–	1	–	4	1	1	–	–	–	–	–	–	7
67	–	–	–	–	1	4	4	1	–	–	–	–	–	–	10
68	–	–	–	1	2	2	2	–	1	1	–	–	–	–	9
69	–	–	–	–	1	2	4	5	5	–	–	1	–	–	18
70	–	–	–	–	1	1	3	2	1	1	1	–	–	–	10
71	–	–	–	–	1	–	3	–	1	2	1	–	–	–	8
72	–	–	–	–	–	–	3	4	1	1	1	–	–	1	11
73	–	–	–	–	–	–	3	2	1	2	1	–	–	–	9
74	–	–	–	–	–	–	2	–	3	–	1	1	–	–	7
75	–	–	–	–	1	–	–	1	–	1	–	1	–	–	4
76	–	–	–	–	–	–	–	–	–	1	–	2	–	–	3
77	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
78	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
79	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1
80	–	–	–	–	–	–	–	–	–	–	–	1	–	–	1
Totals	1	–	2	2	10	15	25	16	14	10	5	6	–	1	107

Table 8 *A*.

Minimum Vertical Diameter of Nerk mm.	1	–	4	6	10	14	15	23	27	30	17	15	12	12	6	3	2	Totals
26	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
27	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
28	–	–	–	–	–	–	–	–	3	1	–	–	–	–	–	–	–	4
29	–	–	1	–	1	1	–	2	2	–	1	–	–	–	–	–	–	8
30	–	–	1	2	–	2	3	–	1	2	–	–	–	–	–	–	–	11
31	–	–	–	3	5	1	4	1	4	6	1	–	–	–	–	–	–	25
32	–	–	1	–	2	4	4	2	9	3	1	1	1	–	–	–	–	28
33	–	–	–	–	1	4	1	6	3	5	4	2	2	2	1	–	–	31
34	–	–	–	1	1	2	2	7	3	1	1	2	1	1	2	–	–	24
35	–	–	–	–	–	–	1	1	–	6	4	5	3	4	1	1	–	26
36	–	–	–	–	–	–	–	3	–	4	2	1	3	1	–	–	1	15
37	–	–	–	–	–	–	–	1	1	1	1	1	1	–	1	2	–	9
38	1	–	–	–	–	–	–	–	1	–	2	–	–	3	1	–	–	8
39	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	1
40	–	–	–	–	–	–	–	–	–	–	–	1	–	1	–	–	1	3
41	–	–	–	–	–	–	–	–	1	–	2	–	–	–	–	–	–	3
Totals	1	–	4	6	10	14	15	23	27	30	17	15	12	12	6	3	2	197

Table 8 *B*.

mm.	1	–	1	4	4	12	19	13	19	20	32	16	23	13	11	9	2	1	Totals
22	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	1
23	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
24	–	–	–	–	–	–	1	–	–	–	1	–	–	–	–	–	–	–	2
25	–	1	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	1
26	–	1	1	4	1	2	2	–	–	–	–	–	–	–	–	–	–	–	10
27	1	1	2	2	2	2	1	1	2	1	–	–	–	–	–	–	–	–	22
28	2	3	2	3	6	10	5	3	1	1	–	–	–	–	–	–	–	–	24
29	–	–	1	2	3	5	4	2	3	1	1	–	–	–	–	–	–	–	28
30	–	1	–	2	4	2	4	3	5	2	1	1	–	–	–	–	–	–	29
31	–	1	–	1	–	1	3	–	2	1	1	1	1	–	–	–	–	–	30
32	–	–	–	–	–	–	5	–	–	2	–	1	–	–	–	–	–	–	12
33	–	–	–	–	–	–	–	1	–	2	1	–	–	–	–	–	–	–	13
34	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	8
35	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
36	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
37	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
38	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
39	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
40	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
41	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Totals	1	–	1	4	4	12	19	13	19	20	32	16	23	13	11	9	2	1	200

Table 8 *C*.

mm.	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	Totals
26	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
27	–	–	–	–	1	1	2	–	–	–	–	–	–	–	–	–	10
28	–	–	–	–	1	2	3	–	–	1	–	–	–	–	–	–	10
29	–	–	–	–	1	2	3	5	4	2	3	1	1	–	–	–	22
30	–	–	–	–	1	2	4	2	4	3	5	2	1	1	–	–	24
31	–	1	–	1	–	1	3	–	2	1	1	1	1	1	–	–	28
32	–	–	–	–	–	–	5	–	–	2	–	1	–	–	–	–	13
33	–	–	–	–	–	–	1	1	–	–	–	–	–	–	–	–	17
34	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	9
35	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	5
36	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
37	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	1

Table 8 *D*.

mm.	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	Totals
26	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	1
27	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
28	–	–	–	–	–	–	2	–	–	–	–	1	–	–	–	–	3
29	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	1
30	1	–	–	1	1	1	2	3	–	–	–	–	–	–	–	–	9
31	–	–	1	3	1	3	3	3	2	3	–	–	–	–	–	–	19
32	–	–	–	–	3	7	4	3	3	–	1	2	–	–	–	–	23
33	1	–	–	–	5	2	11	4	–	5	2	1	–	1	–	–	32
34	–	–	–	–	1	1	8	3	5	4	2	–	–	1	–	–	25
35	–	–	1	–	1	2	3	7	4	1	2	–	–	–	–	–	21
36	–	–	–	–	–	1	3	1	3	–	2	1	–	1	–	1	12
37	–	–	–	1	–	–	–	–	–	1	–	–	–	–	–	–	2
38	–	–	–	–	1	–	–	–	–	–	–	1	1	–	–	–	3
39	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
40	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
41	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Totals	2	–	2	5	14	18	36	24	17	14	9	6	1	3	–	1	151

TABLE 9 *A*. *Oblique Length, External Condyle, ♂ R. Bones.*

Vertical Diameter of Head	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	Totals
40	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	2
41	–	–	2	–	–	–	1	–	–	–	–	–	–	–	–	3
42	1	–	2	–	1	–	1	–	–	–	–	–	–	–	–	5
43	2	3	–	2	2	1	3	1	–	–	–	–	–	–	–	14
44	–	–	4	3	3	2	2	2	1	–	–	–	1	–	–	18
45	–	1	2	4	1	2	3	2	2	–	–	–	–	–	–	17
46	–	–	–	1	5	7	3	8	–	2	2	–	–	–	–	28
47	–	–	–	3	–	8	5	3	3	–	1	–	–	–	–	23
48	–	–	–	–	1	1	2	1	4	5	1	3	–	–	–	18
49	–	–	–	–	1	–	–	8	3	3	2	2	1	1	–	21
50	–	–	–	1	1	–	2	1	3	1	4	2	1	–	1	17
51	–	–	–	–	–	–	–	1	1	–	1	–	3	1	2	8
52	–	–	–	–	–	–	–	1	1	1	–	1	1	–	–	5
53	–	–	–	–	–	–	–	–	–	–	1	–	1	1	–	3
54	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
55	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	1
Totals	4	5	10	14	15	21	23	28	17	13	11	12	6	3	1	183

TABLE 9 *B*. *Oblique Length, External Condyle, ♂ L. Bones.*

Vertical Diameter of Head	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	Totals
40	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	1
41	–	–	–	1	–	–	1	2	–	–	1	–	–	–	–	–	–	–	5
42	–	–	1	1	–	–	1	1	–	2	1	–	–	–	–	–	–	–	7
43	1	–	–	1	2	1	3	1	3	–	1	–	–	–	–	–	–	–	13
44	–	–	–	1	–	3	2	3	4	3	2	1	2	–	–	–	–	–	21
45	–	–	–	–	1	–	2	3	5	2	6	1	–	–	–	–	–	–	20
46	–	–	–	–	–	4	5	–	2	3	3	2	3	2	1	–	–	–	25
47	–	–	–	–	–	1	2	1	3	3	7	3	5	1	–	1	–	–	27
48	–	–	–	–	–	–	2	1	2	2	1	2	1	1	1	–	1	–	14
49	–	–	–	–	–	–	1	–	1	–	5	3	6	4	2	4	–	–	26
50	–	–	–	–	–	–	–	–	–	–	2	2	–	2	–	–	–	1	7
51	–	–	–	–	–	–	–	–	–	1	2	1	2	1	3	1	–	–	11
52	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1	–	–	2
53	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	1
54	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
55	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1
Totals	1	–	1	4	3	10	19	12	20	16	31	15	19	12	9	7	1	1	181

TABLE 9 *C*. *Oblique Length, External Condyle, ♀ R. Bones.*

Vertical Diameter of Head	50	51	52	53	54	55	56	57	58	59	60	61	62	–	Totals
34	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
35	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
36	–	1	–	–	–	–	–	–	–	–	–	–	–	–	1
37	–	1	1	1	1	1	–	–	–	–	–	–	–	–	5
38	1	1	–	2	–	–	–	–	1	–	–	–	–	–	5
39	–	1	2	3	5	9	5	1	–	1	–	–	–	–	27
40	–	2	4	4	3	3	4	1	1	–	–	–	–	–	22
41	–	–	–	1	2	6	6	2	3	1	1	–	–	–	22
42	1	1	–	1	3	1	1	4	6	1	1	–	–	–	20
43	–	–	–	1	1	1	5	1	–	2	–	1	1	–	13
44	–	–	–	–	–	–	2	–	–	–	–	1	–	–	3
45	–	–	–	–	–	–	2	1	–	1	–	–	–	–	4
46	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1
47	–	–	–	–	–	–	–	–	–	–	–	1	–	–	1
48	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
49	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Totals	2	7	7	13	15	21	25	10	11	6	2	3	2	–	124

TABLE 9 *D*. *Oblique Length, External Condyle, ♀ L. Bones.*

Vertical Diameter of Head	48	49	50	51	52	53	54	55	56	57	58	59	60	61	Totals
34	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
35	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
36	1	–	–	1	1	1	1	–	–	–	–	–	–	–	5
37	–	–	1	1	1	3	–	1	–	–	–	–	–	–	7
38	–	–	–	2	1	3	1	–	–	1	–	–	–	–	8
39	–	–	1	–	4	3	2	1	1	–	2	–	–	–	17
40	–	–	–	1	2	9	4	3	3	1	–	–	–	–	23
41	1	–	–	–	3	2	6	7	3	–	1	–	–	–	23
42	–	–	–	–	1	2	6	4	5	6	2	2	–	1	29
43	–	–	–	–	–	1	4	2	2	–	1	1	–	1	12
44	–	–	–	–	–	–	–	–	1	2	2	–	–	–	5
45	–	–	–	–	2	–	–	–	–	–	–	1	–	1	4
46	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
47	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
48	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
49	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Totals	2	–	2	4	13	18	30	20	15	13	7	6	–	3	133

TABLE 10 *A*. *Minimum Vertical Diameter of Neck, ♂ R. Bones.*

Bicondylar Width	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	Totals
70	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
71	–	–	–	–	1	–	1	–	–	–	–	–	–	–	–	2
72	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	1
73	–	1	–	–	1	–	–	–	–	–	–	–	–	–	–	2
74	–	–	1	3	1	1	–	–	–	–	–	–	–	–	–	6
75	1	–	–	3	1	2	3	–	–	–	–	–	–	–	–	10
76	–	–	1	1	3	4	–	–	–	1	–	–	–	–	–	10
77	–	–	–	2	3	2	1	2	1	–	–	–	–	–	–	11
78	–	–	–	–	4	4	3	4	1	1	1	1	–	–	–	19
79	–	1	1	1	1	3	2	–	1	–	–	–	–	–	–	10
80	–	–	–	–	1	2	5	4	1	1	2	–	–	–	–	16
81	–	–	–	–	–	1	8	3	3	–	–	–	–	–	–	15
82	–	–	–	1	–	1	1	–	2	1	–	1	–	–	1	8
83	–	–	–	–	–	–	1	–	5	2	1	–	–	–	–	9
84	–	–	1	–	–	–	2	2	2	2	1	–	–	–	1	11
85	–	–	–	–	–	–	1	1	3	1	1	1	–	1	1	10
86	–	–	–	–	–	–	–	1	2	2	1	–	–	1	–	7
87	–	–	–	–	–	–	–	–	–	–	1	2	–	–	–	3
88	–	–	–	–	–	–	–	–	1	–	–	1	–	–	–	2
89	–	–	–	–	–	–	–	–	–	–	–	1	1	–	–	2
Totals	1	2	5	11	16	20	28	17	22	11	8	7	1	2	3	154

TABLE 10 *B*. *Minimum Vertical Diameter of Neck, ♂ L. Bones.*

Bicondylar Width	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	–	–	Totals
70	–	1	–	–	–	1	–	–	1	–	–	–	–	–	–	–	–	–	3
71	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
72	1	–	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	3
73	–	–	–	–	1	2	–	–	1	1	1	–	–	–	–	–	–	–	6
74	–	–	–	–	1	2	3	–	1	–	–	–	–	–	–	–	–	–	7
75	–	1	–	1	3	4	5	1	1	1	–	–	–	–	–	–	–	–	17
76	–	–	–	1	–	2	2	3	–	–	–	–	–	–	–	–	–	–	8
77	–	–	–	–	–	1	2	6	–	2	1	–	1	–	–	–	–	–	13
78	–	–	–	–	2	1	2	2	2	2	1	–	–	–	–	–	–	–	12
79	–	–	–	–	1	–	2	4	2	1	–	1	–	–	–	–	–	–	11
80	–	–	–	–	–	2	1	3	4	3	1	1	1	–	–	–	–	–	16
81	–	–	–	–	–	–	2	4	2	–	3	1	–	–	1	–	–	–	13
82	–	–	–	–	–	–	2	6	–	3	1	–	1	–	–	–	–	–	13
83	–	–	–	–	–	2	–	–	1	4	–	1	–	1	–	–	–	–	9
84	–	–	–	–	–	–	1	2	1	–	–	–	2	–	–	–	–	–	6
85	–	–	–	–	–	–	–	–	–	2	5	2	–	1	–	–	–	–	10
86	–	–	–	–	–	–	–	–	2	–	2	3	–	–	–	–	–	–	7
87	–	–	–	–	–	–	–	–	1	–	2	–	–	–	–	–	–	–	3
88	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
89	–	–	–	–	–	–	–	–	–	–	–	1	1	–	–	–	–	–	2
Totals	1	2	–	3	9	15	18	22	24	21	11	16	9	6	1	1	–	–	159

TABLE 10 *C*. *Minimum Vertical Diameter of Neck, ♀ R. Bones*

Bicondylar Width	24	25	26	27	28	29	30	31	32	33	34	35	36	37	Totals
61	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
62	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
63	–	–	–	2	–	–	–	–	–	–	–	–	–	–	2
64	–	–	2	–	1	–	–	–	–	–	–	–	–	1	4
65	–	–	1	1	2	1	–	1	–	–	–	–	–	–	6
66	1	–	–	1	1	3	–	–	–	–	–	–	–	–	6
67	–	1	–	–	2	2	1	–	–	–	–	–	–	–	6
68	–	–	1	–	2	5	1	–	–	–	–	–	–	–	9
69	–	–	3	2	3	1	1	1	–	–	–	–	–	–	11
70	–	–	–	–	–	4	1	–	1	–	–	–	–	–	6
71	–	1	1	3	3	–	4	1	–	–	–	–	–	–	13
72	–	–	1	2	4	3	4	1	1	–	–	1	–	–	17
73	–	–	1	–	–	–	2	1	–	–	–	–	–	–	4
74	–	–	–	–	1	–	2	–	–	1	–	–	–	–	4
75	–	–	–	–	1	–	2	2	–	–	–	–	–	–	5
76	–	–	–	–	1	–	–	–	1	–	–	–	–	–	2
77	–	–	–	–	–	–	1	1	–	–	–	–	–	–	2
78	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
79	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
80	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Totals	1	2	10	11	25	16	18	9	2	1	–	1	–	1	97

TABLE 10 *D*. *Minimum Vertical Diameter of Neck, ♀ L. Bones.*

Bicondylar Width	22	23	24	25	26	27	28	29	30	31	32	33	34	–	Totals
61	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1
62	–	–	–	–	–	1	–	–	–	–	–	–	–	–	1
63	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
64	1	–	–	–	–	1	–	–	–	–	–	–	–	–	2
65	–	–	–	1	–	1	1	1	2	1	–	–	–	–	7
66	–	–	–	–	2	1	4	1	–	–	–	–	–	–	8
67	–	–	1	–	–	2	5	–	1	1	–	–	–	–	10
68	–	–	–	–	1	3	2	3	–	1	1	–	–	–	11
69	–	–	–	–	–	2	6	4	4	1	–	–	–	–	17
70	–	–	–	–	2	–	1	4	1	–	–	–	–	–	11
71	–	–	–	–	–	–	1	3	2	1	2	–	–	–	9
72	–	–	–	–	1	1	–	5	3	–	1	–	–	–	11
73	–	–	–	–	–	1	–	4	2	2	–	–	–	–	9
74	–	–	–	–	–	1	1	–	2	1	2	–	–	–	7
75	–	–	–	–	–	–	–	1	1	–	–	2	–	–	4
76	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
77	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
78	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
79	–	–	–	–	–	–	–	–	1	–	–	–	–	–	1
80	–	–	1	–	–	–	–	–	–	–	–	–	–	–	1
Totals	1	–	2	1	7	14	22	26	18	12	7	–	2	–	112

CHAPTER V

THE VARIABILITY OF THE ENGLISH FEMUR, ITS COMPARISON WITH THAT OF OTHER RACES AND OF OTHER BONES, AND THE INFLUENCE OF SIDE AND SEX

(i) *Tabulated Results and General Remarks.*

Our results are arranged in the following four tables. Table I gives the standard deviations of the absolute measurements, both lengths and angles. Table II gives the standard deviations of the indices. Table III gives the coefficients of variation—that is the percentage of the standard deviation or variability on the mean values of the characters for the absolute measurements, and Table IV provides the coefficients of variation for the indices. We do not here enter at length into the question of the meaning of the coefficient of variation in the case of angles or of indices. We believe it to be a truer measure of variation in an absolute length than a standard deviation. What is quite clear is that it would be absurd to compare the standard deviation of the vertical diameter of the head with that of the trochanteric length in order to determine which feature is the more variable, but their coefficients of variation can be reasonably compared. We may look at the matter from the following illustrative standpoint: Suppose the female to be only a somewhat reduced male. Then we may suppose the female individual population to be obtained from the male by multiplying each individual male by the reducing factor λ, which might well be taken to be the ratio of type female to type male. After this process every single angle and every single index of the female individual population would correspond to those of some individual male—in other words *no change at all would have taken place in the variabilities of angles and of indices.* On the other hand the variabilities of absolute female measurements would be the male variabilities multiplied by λ, or reduced in the same ratio as the absolute lengths themselves. For this reason, if we take λ to be the ratio of the types, it is clear that the coefficient of variation is a reasonable measure of the *relative* variability of absolute measurements. The use of this coefficient however is less justifiable in the case of indices or angles, where the idea of absolute size is already removed. We could for example conceive a race[1] in which the mean torsional angle as in the orang is practically zero by the balancing of positive and negative torsions. In such a case the standard deviation of the angle would give real information, but to say that its coefficient of variation was infinite would not convey any useful information as to the variability of the angle.

[1] Say the Veddah: see Rodriguez, Bibl. 101.

TABLE I. *Standard Deviations. Absolute Measurements (Lengths in mm.).*

Key Letters	Character	Males				Females			
		No.	Right	No.	Left	No.	Right	No.	Left
(*a*)	Maximum Length	218	22·269 ± ·719	225	22·303 ± ·709	171	20·114 ± ·734	181	21·055 ± ·746
(*b*)	Trochanteric Length	187	20·628 ± ·720	209	21·364 ± ·705	144	19·121 ± ·720	163	19·555 ± ·731
(*c*)	Max. Troch. Length	183	20·873 ± ·736	206	21·986 ± ·731	140	19·100 ± ·770	158	20·025 ± ·760
(*d*)	Oblique Length	202	21·676 ± ·727	214	22·131 ± ·721	161	20·118 ± ·756	169	20·912 ± ·767
(*e*)	Troch. Oblique Length	173	20·593 ± ·747	194	21·482 ± ·736	136	19·270 ± ·788	149	19·474 ± ·761
(*f*)	Vert. Diam. of Head	204	2·887 ± ·096	212	2·797 ± ·092	151	2·077 ± ·081	168	2·000 ± ·074
(*g*)	Horiz. Diam. of Head	180	2·826 ± ·100	196	2·599 ± ·089	135	2·039 ± ·084	156	1·992 ± ·076
(n_h)	Horiz. Diam. of Neck	225	2·199 ± ·070	235	2·040 ± ·063	164	1·705 ± ·063	186	1·766 ± ·062
(n_v)	Vert. Diam. of Neck	225	2·695 ± ·086	235	2·635 ± ·082	164	1·982 ± ·074	186	1·965 ± ·069
(*h*)	Platymeric Ant. Post. Diam.	236	1·902 ± ·059	247	1·993 ± ·060	178	1·756 ± ·063	193	1·637 ± ·056
(*i*)	Platymeric Trans. Diam.	236	2·946 ± ·091	247	2·759 ± ·084	178	2·565 ± ·092	193	2·279 ± ·078
(*k*)	Pilastric Ant. Post. Diam.	237	2·282 ± ·071	250	2·410 ± ·073	185	2·028 ± ·071	196	2·121 ± ·072
(*l*)	Pilastric Trans. Diam.	237	2·183 ± ·068	250	2·051 ± ·062	185	1·945 ± ·068	196	2·034 ± ·069
(*n*)	Popliteal Length...	230	16·899 ± ·531	243	15·481 ± ·474	181	14·986 ± ·531	192	15·863 ± ·546
(*o*)	Popliteal Breadth	232	3·972 ± ·124	239	3·913 ± ·123	182	3·405 ± ·120	188	3·176 ± ·110
(*p*)	Popliteal Dir. Ant. Post. Diam. ...	228	2·386 ± ·075	238	2·624 ± ·081	182	2·374 ± ·084	188	1·849 ± ·064
(*q*)	Popliteal Obl. Ant. Post. Diam. ...	233	2·449 ± ·077	235	2·568 ± ·080	181	2·146 ± 076	184	1·901 ± ·067
(*s*)	Bicondylar Width	153	4·025 ± ·155	166	4·109 ± ·152	102	3·393 ± ·160	114	3·458 ± ·154
(σ_1)	Max. Length Ext. Condyle	196	3·170 ± ·108	193	3·104 ± ·107	140	2·739 ± ·110	143	2·570 ± ·102
(σ_2)	Max. Length Int. Condyle	203	3·577 ± ·120	215	3·458 ± ·112	153	2·905 ± ·112	162	2·992 ± ·112
(σ_1')	Oblique Length Ext. Condyle	207	3·073 ± ·102	209	3·116 ± ·103	147	2·659 ± ·105	152	2·340 ± ·091
(β_1)	Ext. Condyle Horiz. Band-radius ...	160	1·919 ± ·072	178	1·812 ± ·065	112	1·667 ± ·075	115	1·631 ± ·073
(β_2)	Ext. Condyle Vert. Band-radius ...	165	1·787 ± ·066	180	1·721 ± ·061	120	1·627 ± ·071	121	1·569 ± ·068
(A_2)	Diaphysial Subtense	234	1·821 ± ·057	242	1·775 ± ·054	172	1·755 ± ·064	189	1·623 ± ·056
(A_1)	Diaphysial Chord	234	19·286 ± ·601	242	19·275 ± ·591	172	18·301 ± ·666	189	18·241 ± ·633
(*t*)	Capito-Collar Length	227	7·110 ± ·225	229	6·884 ± ·217	167	6·331 ± ·234	182	6·240 ± ·221
(*u*)	Length of Shaft	227	20·837 ± ·660	229	20·983 ± ·661	167	20·539 ± ·758	182	18·514 ± ·654
(*v*)	Capito-Trochlear Length	227	22·286 ± ·706	229	21·650 ± ·682	167	21·219 ± ·783	182	20·125 ± ·711
(ω_1)	Midtrochlear Angle	227	1·251 ± ·040	229	1·231 ± ·039	167	1·364 ± ·050	182	1·319 ± ·047
(ω_2)	Angle at Centre of Head	227	5·627 ± ·178	229	5·491 ± ·173	167	6·066 ± ·224	182	6·313 ± ·223
(*w*)	Collar or Cervical Angle	227	6·682 ± ·212	229	6·509 ± ·205	167	7·104 ± ·262	182	7·424 ± ·262
(x_2)	Torsion of Shaft	208	12·065 ± ·399	211	12·070 ± ·396	151	12·594 ± ·489	165	11·640 ± ·432
(x_1)	*Torsional Angle	199	8·801 ± ·298	210	9·179 ± ·302	151	10·166 ± ·395	162	9·727 ± ·364
($x_2 - x_1$)	Retorsional Angle	193	10·772 ± ·370	196	8·617 ± ·294	140	9·865 ± ·398	153	7·623 ± ·294
(*y*)	Obliquity of Shaft	218	2·018 ± ·065	233	1·890 ± ·059	166	2·135 ± ·079	175	1·890 ± ·068
	*Torsional Angle Disregarding Sign ...	199	8·123 ± ·275	210	8·733 ± ·287	151	9·295 ± ·361	162	9·680 ± ·362

(In degrees)

Table II. *Standard Deviations. Indices.*

	Key Letters	Name of Index	Characters' Ratio	♂ R.		♂ L.		♀ R.		♀ L.	
Shaft Section Indices	(*j*)	Platymeric Index	Platymeric A. P. Diameter/Platymeric Transverse ...	236	8·765 ± ·272	247	9·347 ± ·284	179	9·606 ± ·342	193	8·194 ± ·281
	(*m*)	Pilastric Index	Pilastric A. P. Diameter/Pilastric Transverse	237	9·532 ± ·295	250	9·263 ± ·279	185	9·166 ± ·321	195	9·423 ± ·322
	(*r*)	Popliteal Index	Popliteal Direct A. P. Diameter/Popliteal Width ...	225	6·325 ± ·201	236	6·403 ± ·199	181	5·673 ± ·201	184	5·727 ± ·201
	(*ll*)	Index of Popliteal Skewness	Popliteal Direct A. P. Diameter/Popliteal Oblique A. P.	228	3·626 ± ·115	235	3·811 ± ·119	179	3·814 ± ·136	184	3·961 ± ·139
Head Indices	(*dd*)	Ellipticity of Head	Horizontal Diameter of Head/Vertical Diam. of Head	176	1·812 ± ·065	190	1·925 ± ·066	130	1·709 ± ·071	149	1·504 ± ·059
	(*ee*)	Head-Bust Ratio	Vertical Diameter of Head/Capito-collar Length ...	197	5·544 ± ·188	204	5·435 ± ·181	146	5·589 ± ·221	160	5·561 ± ·210
	(*FF*)	Neck-Head Index	Horizontal Diameter of Neck/Horizontal Diam. of Head	178	3·468 ± ·124	192	3·295 ± ·113	130	3·322 ± ·139	150	3·535 ± ·138
	(*ww*)	Capito-Bicondylar Ratio ...	Vertical Diameter of Head/Bicondylar Width ...	143	2·252 ± ·090	146	2·388 ± ·094	88	2·424 ± ·123	102	2·157 ± ·102
	(*uu*)	Robusticity of Head ...	Sum of Diameters of Head/Oblique Length	161	1·076 ± ·040	174	1·059 ± ·038	115	1·034 ± ·046	131	1·020 ± ·043
	(*oo*)	Capital Ratio	Vertical Diameter of Head/Maximum Length	192	·532 ± ·018	198	·555 ± ·019	142	·532 ± ·021	154	·554 ± ·021
Bust Indices	(*EE*)	Ellipticity of Neck	Horizontal Diameter of Neck/Vertical Diam. of Neck	224	5·922 ± ·189	235	4·896 ± ·152	164	5·846 ± ·218	186	5·203 ± ·182
	(*gg*)	Epiphysial Ratio	Capito-Collar Length/Bicondylar Width	149	8·352 ± ·326	157	8·481 ± ·323	96	9·849 ± ·479*	105	7·739 ± ·360
	(*pp*)	Primary Bust Ratio ...	Capito-Collar Length/Maximum Length	213	1·587 ± ·052	214	1·635 ± ·053	157	1·698 ± ·065	169	1·711 ± ·063
	(*rr*)	Secondary Bust Ratio ...	Capito-Collar Length/Oblique Length	199	1·571 ± ·052	206	1 593 ± ·053	147	1·744 ± ·069	158	1·709 ± ·065
	(*ff*)	Bust-Shaft Index	Capito-Collar Length/Length of Shaft	227	2·183 ± ·069	229	2·165 ± ·068	167	2·406 ± ·089*	182	2·166 ± ·077
Shaft Indices	(*hh*)	Index of Gracility (Upper)...	Pilastric Transverse Diameter/Platymeric Transverse...	236	5·525 ± ·172	247	5·341 ± ·162	179	5·801 ± ·207	193	5·353 ± ·184
	(*ii*)	Index of Gracility (Lower)...	Pilastric Transverse Diameter/Popliteal Width ...	230	6·517 ± ·205	239	6·429 ± ·198	180	6·114 ± ·217	184	6·780 ± ·238
	(*jj*)	Index of Trans. Slenderness	Pilastric Transverse Diameter/Length of Shaft ...	226	·641 ± ·020	228	·629 ± ·020	167	·662 ± ·024	180	·667 ± ·024
	(*kk*)	Index of Sagittal Slenderness	Pilastric A. P. Diameter/Length of Shaft	226	·644 ± ·020	228	·610 ± ·019	167	·641 ± ·024	180	·550 ± ·020
	(*tt*)	Robusticity of Femur ...	Sum of Pilastric Diameters/Oblique Length	203	·789 ± ·026	214	·729 ± ·024	160	·855 ± ·032	165	·826 ± ·031
	(*B*)	Primary Index of Bowing ...	Diaphysial Subtense/Diaphysial Chord...	234	·699 ± ·022	242	·660 ± ·020	172	·716 ± ·026	189	·673 ± ·023
	(*zz*)	Secondary Index of Bowing	Proximal Segment of Diaphysial Chord/Diaphysial Chord	240	6·741 ± ·208	242	7·571 ± ·232	170	9·274 ± ·339	190	8·992 ± ·311
Popliteal Indices	(*cc*)	Pyramidal Popliteal Index...	Popliteal Width/Popliteal Length	225	4·760 ± ·151	237	4·303 ± ·133	178	4·469 ± ·160	183	4·881 ± ·172
	(*bb*)	Soffit Index	Popliteal Width/Bicondylar Width	150	4·166 ± ·162	163	4·371 ± ·163	99	4·092 ± ·196	111	4·096 ± ·185
	(*yy*)	Popliteal-Shaft Ratio ...	Popliteal Length/Length of Shaft	222	4·127 ± ·132	223	4·128 ± ·132	166	4·269 ± ·158	178	4·318 ± ·154
Condylar Indices	(*vv*)	Condylar Index	External Condyle Length/Bicondylar Width ...	138	2·726 ± ·111	141	2·725 ± ·109	88	3·507 ± ·178	100	3·032 ± ·145
	(*xx*)	Condylar Lengths Index ...	External Condyle Length/Internal Condyle Length ...	175	3·797 ± ·137	181	3·461 ± ·123	127	4·037 ± ·171	132	4·129 ± ·171
	(I_β)	Band-radial Index	Horizontal Band-radius/Vertical Band-radius	160	12·027 ± ·454	177	11·033 ± ·396	112	10·648 ± ·480	115	10·465 ± ·465
	(*ss*)	Condylar Trochanteric Ratio	External Condyle Length/Trochanteric Length ...	160	·643 ± ·024	176	·638 ± ·023	119	·746 ± ·033	128	·777 ± ·033
	(*aa*)	Bicondylar Ratio	Bicondylar Width/Maximum Length	152	·817 ± ·032	161	·870 ± ·033	99	·974 ± ·047	112	·886 ± ·040
	(*qq*)	Bicondylar Trochanteric Ratio	Bicondylar Width/Trochanteric Length	135	·834 ± ·034	148	·946 ± ·037	93	·993 ± ·049	104	·906 ± ·042
Lengths Indices	(*mm*)	Oblique Max. Lengths Index	Oblique Length/Maximum Length	203	·419 ± ·014	214	·418 ± ·014	159	·472 ± ·018	167	·438 ± ·016
	(*nn*)	Oblique Max. Trochant. Index	Oblique Trochanteric/Maximum Trochanteric Length	172	·441 ± ·016	195	·411 ± ·014	135	·571 ± ·023	147	·478 ± ·019

* See footnotes to corresponding values of the Coefficients of Variation for Epiphysial Ratio and Bust-Shaft Index in Table IV.

TABLE III. *Coefficients of Variation. Absolute Measurements.*

Key Letters	Character	Males				Females			
		No.	Right	No.	Left	No.	Right	No.	Left
(*a*)	Maximum Length	218	4·984 ± ·161	225	4·959 ± ·158	171	4·904 ± ·179	181	5·157 ± ·183
(*b*)	Trochanteric Length	187	4·842 ± ·169	209	5·020 ± ·166	144	4·907 ± ·195	163	5·033 ± ·189
(*c*)	Max. Troch. Length	183	4·797 ± ·170	206	5·065 ± ·169	140	4·804 ± ·194	158	5·032 ± ·191
(*d*)	Oblique Length	202	4·878 ± ·164	214	4·968 ± ·162	161	4·950 ± ·187	169	5·161 ± ·190
(*e*)	Troch. Oblique Length	173	4·862 ± ·177	194	5·073 ± ·174	136	4·998 ± ·205	149	5·047 ± ·198
(*f*)	Vert. Diam. of Head	204	6·135 ± ·206	212	5·980 ± ·197	151	5·052 ± ·197	168	4·907 ± ·181
(*g*)	Horiz. Diam. of Head	180	6·064 ± ·216	196	5·604 ± ·192	135	5·009 ± ·206	156	4·919 ± ·188
(n_h)	Horiz. Diam. of Neck	225	8·539 ± ·274	235	7·968 ± ·249	164	7·492 ± ·281	186	7·862 ± ·277
(n_v)	Vert. Diam. of Neck	225	7·960 ± ·255	235	7·697 ± ·241	164	6·745 ± ·252	186	6·657 ± ·234
(*h*)	Platymeric Ant. Post. Diam. ...	236	7·089 ± ·221	247	7·478 ± ·228	178	7·370 ± ·265	193	7·013 ± ·242
(*i*)	Platymeric Trans. Diam.	236	9·299 ± ·291	247	8·751 ± ·268	178	8·976 ± ·323	193	7·946 ± ·275
(*k*)	Pilastric Ant. Post. Diam.	237	7·727 ± ·241	250	8·405 ± ·255	185	7·783 ± ·275	196	8·427 ± ·289
(*l*)	Pilastric Trans. Diam.	237	7·791 ± ·243	250	7·340 ± ·223	185	7·718 ± ·272	196	8·020 ± ·275
(*n*)	Popliteal Length	230	13·952 ± ·447	243	12·653 ± ·381	181	13·380 ± ·483	192	14·388 ± ·505
(*o*)	Popliteal Breadth	232	9·971 ± ·315	239	9·812 ± ·314	182	9·386 ± ·335	188	8·943 ± ·314
(*p*)	Popliteal Dir. Ant. Post. Diam. ...	228	8·674 ± ·276	238	9·415 ± ·294	182	9·782 ± ·349	188	7·584 ± ·265
(*q*)	Popliteal Obl. Ant. Post. Diam. ...	233	7·959 ± ·250	235	8·386 ± ·263	181	8·008 ± ·286	184	7·091 ± ·251
(*s*)	Bicondylar Width	153	5·022 ± ·194	166	5·175 ± ·192	102	4·839 ± ·229	114	4·948 ± ·222
(σ_1)	Max. Length Ext. Condyle ...	196	5·049 ± ·172	193	4·999 ± ·172	140	4·856 ± ·196	143	4·603 ± ·184
(σ_2)	Max. Length Int. Condyle ...	203	5·758 ± ·193	215	5·577 ± ·182	153	5·228 ± ·215	162	5·385 ± ·202
(σ_1')	Oblique Length Ext. Condyle ...	207	4·968 ± ·165	209	5·104 ± ·169	147	4·765 ± ·188	152	4·241 ± ·164
(β_1)	Ext. Condyle Horiz. Band-radius ...	160	10·258 ± ·391	178	9·498 ± ·343	112	10·016 ± ·456	115	9·668 ± ·434
(β_2)	Ext. Condyle Vert. Band-radius ...	165	8·561 ± ·320	180	8·283 ± ·296	120	8 782 ± ·385	121	8·516 ± ·372
(A_2)	Diaphysial Subtense	234	27·719 ± ·928	242	27·701 ± ·912	172	30·392 ± 1·203	189	28·532 ± 1·067
(A_1)	Diaphysial Chord	234	7·634 ± ·239	242	7·625 ± ·235	172	8·005 ± ·293	189	8·068 ± ·282
(*t*)	Capito-Collar Length	227	9·229 ± ·295	229	8·916 ± ·283	167	9·259 ± ·345	182	9·259 ± ·330
(*u*)	Length of Shaft	227	5·513 ± ·175	229	5·578 ± ·176	167	5·904 ± ·219	182	5·326 ± ·189
(*v*)	Capito-Trochlear Length	227	5·154 ± ·164	229	5 010 ± ·158	167	5·381 ± ·199	182	5·112 ± ·181
(ω_1)	Midtrochlear Angle	227	15·965 ± ·518	229	11·233 ± ·359	167	17·418 ± ·662	182	17·242 ± ·627
(ω_2)	Angle at Centre of Head	227	13·376 ± ·431	229	13·371 ± ·429	167	14·097 ± ·531	182	14·875 ± ·537
(w)	Collar or Cervical Angle	227	5·124 ± ·163	229	4·950 ± ·156	167	5·490 ± ·203	182	5·699 ± ·202
(x_2)	Torsion of Shaft	208	55·446 ± 2·331	211	45·153 ± 1·759	151	57·115 ± 2·849	165	40·470 ± 1·731
(x_1)	*Torsional Angle	199	75·691 ± 3·749	210	62·413 ± 2·740	151	71·380 ± 3·940	162	54·354 ± 2·569
($x_2 - x_1$)	Retorsional Angle	193	110·670 ± 7·055	196	67·703 ± 3·193	140	122·214 ± 9·838	153	73·379 ± 4·077
(y)	Obliquity of Shaft	218	23·234 ± ·782	233	16·300 ± ·570	166	22·734 ± ·884	175	16·058 ± ·593
	*Torsional Angle Disregarding Sign	199	67·119 ± 3·129	210	58·306 ± 2·487	151	62·531 ± 3·240	162	54·019 ± 2·547

TABLE IV. *Coefficients of Variation. Indices.*

Key Letters	Name of Index	♂ R.		♂ L.		♀ R.		♀ L.	
(*j*)	Platymeric Index	236	10·272 ± ·322	247	10·982 ± ·337	179	11·425 ± ·413	193	10·024 ± ·348
(*m*)	Pilastric Index	237	9·009 ± ·281	250	8·981 ± ·273	185	8·826 ± ·312	195	9·472 ± ·326
(*r*)	Popliteal Index	225	8·947 ± ·287	236	9·034 ± ·283	181	8·460 ± ·302	184	8·329 ± ·295
(*ll*)	Index of Popliteal Skewness	228	3·988 ± ·126	235	4·187 ± ·130	179	4·227 ± ·151	184	4·357 ± ·153
(*dd*)	Ellipticity of Head	176	1·834 ± ·066	190	1·946 ± ·067	130	1·722 ± ·072	149	1·519 ± ·059
(*ee*)	Head-Bust Ratio	197	9·022 ± ·309	204	8·882 ± ·299	146	9·236 ± ·368	160	9·135 ± ·347
(*FF*)	Neck-Head Index	178	6·257 ± ·225	192	5·981 ± ·207	130	5·971 ± ·251	150	6·375 ± ·249
(*ww*)	Capito-bicondylar Ratio	143	3·829 ± ·153	146	4·031 ± ·159	88	4·162 ± ·212	102	3·705 ± ·175
(*uu*)	Robusticity of Head	161	5·106 ± ·192	174	5·045 ± ·183	115	5·102 ± ·227	131	5·074 ± ·212
(*oo*)	Capital Ratio	192	5·060 ± ·175	198	5 293 ± ·180	142	5·291 ± ·212	154	5·535 ± ·214
(*EE*)	Ellipticity of Neck	224	7·750 ± ·248	235	6·528 ± ·204	164	7·532 ± ·282	186	6·819 ± ·240
(*gg*)	Epiphysial Ratio	149	8·694 ± ·342	157	8·684 ± ·333	96	10·179 ± ·501*	105	8·084 ± ·379
(*pp*)	Primary Bust Ratio	213	9·218 ± ·304	214	9·470 ± ·312	157	10·156 ± ·391	169	10·311 ± ·382
(*rr*)	Secondary Bust Ratio	199	9·063 ± ·309	206	9·177 ± ·308	147	10·368 ± ·412	158	10·206 ± ·391
(*ff*)	Bust Shaft Index	227	10·709 ± ·343	229	10·517 ± ·335	167	12·157 ± ·455†	182	11·135 ± ·398
(*hh*)	Index of Gracility (Upper)	236	6·223 ± ·194	247	6·010 ± ·183	179	6·558 ± ·235	193	6·033 ± ·208
(*ii*)	Index of Gracility (Lower)	230	9·213 ± ·292	239	9·012 ± ·280	180	8·766 ± ·314	184	9·451 ± ·335
(*jj*)	Index of Transverse Slenderness	226	8 630 ± ·276	228	8·459 ± ·269	167	9·132 ± ·340	180	9·136 ± ·327
(*kk*)	Index of Sagittal Slenderness	226	8·230 ± ·263	228	8·022 ± ·255	167	8·532 ± ·317	180	7·627 ± ·273
(*tt*)	Robusticity of Femur	203	6·241 ± ·210	214	5·727 ± ·188	160	6·756 ± ·256	165	6·615 ± ·247
(*B*)	Primary Index of Bowing	234	27·016 ± ·902	242	26·258 ± ·859	172	28·580 ± 1·121	189	26·911 ± ·999
(*zz*)	Secondary Index of Bowing	240	18·174 ± ·817	242	19·612 ± ·883	172	23·498 ± 1·281	189	21·096 ± 1·077
(*cc*)	Pyramidal Popliteal Index	225	14·245 ± ·462	237	13·160 ± ·415	178	13·630 ± ·496	183	14·846 ± ·535
(*bb*)	Soffit Index	150	8·352 ± ·328	163	8·728 ± ·329	99	8·068 ± ·389	111	8·053 ± ·367
(*yy*)	Popliteal Shaft Index	222	12·887 ± ·419	223	12·690 ± ·412	166	13·235 ± ·498	178	13·607 ± ·495
(*vv*)	Condylar Index	138	3·483 ± ·142	141	3·498 ± ·141	88	4·374 ± ·223	100	3·805 ± ·183
(*xx*)	Condylar Lengths Index	175	3·766 ± ·136	181	3·465 ± ·123	127	3·992 ± ·169	132	4·110 ± ·171
(I_β)	Band-radial Index	160	10·690 ± ·408	177	10·055 ± ·364	112	9·501 ± ·432	115	9·555 ± ·429
(*ss*)	Condylar Trochanteric Ratio	160	4 366 ± ·165	176	4·372 ± ·157	119	5·124 ± ·225	128	5·392 ± ·228
(*aa*)	Bicondylar Ratio	152	4·554 ± ·179	161	4·908 ± ·185	99	5·625 ± ·270	112	5·154 ± ·233
(*qq*)	Bicondylar Trochanteric Ratio	135	4·431 ± ·182	148	5·052 ± ·199	93	5·450 ± ·270	104	5·017 ± ·235
(*mm*)	Oblique-Maximum Lengths Index	203	·422 ± ·014	214	·420 ± ·014	159	·476 ± ·018	167	·442 ± ·016
(*nn*)	Oblique-Maximum Trochanteric Index	172	·443 ± ·016	195	·413 ± ·014	135	·575 ± ·024	147	·481 ± ·019

* If we omit an extreme case, probably abnormal, of Epiphysial Ratio we have ♀ R.: Mean = 96·87, S.D. = 9·476, C. of V. = 9·783, values agreeing better with ♀ L.

† Omitting a most probably abnormal case of Bust-Shaft Index we have ♀ R.: Mean = 19·727, S.D. = 2·259, C. of V. = 11·451, values agreeing better with ♀ L.

Again the obliquity in the case of the individual chimpanzee may be zero or even negative; suppose a being in which it was truly zero in the type, shall we say that its variation is infinite? If so, why not take the obliquity to be measured from the horizontal instead of the vertical? The type will now be 90° and the variation cease to be infinite! Clearly the variation of angles, and, we may add, of indices, is of a different character to that of absolute sizes. In the latter case the size of the character is determined by the existence of a certain number of cells and by the size of those cells. If all cells were of the same size (s) and the distribution of their number followed the binomial law we might anticipate that the mean would be of form nqs and the standard deviation of the form $\sqrt{npq} \times s$. In this case the coefficient S.D./$\sqrt{\text{mean}} = \sqrt{p} \times s$ might possibly approximate to a constant; but, if s be on the whole constant, p must have very different values for different characters to judge by applying such a formula to our data[1].

On such hypothesis the coefficient of variation would be $\frac{1}{\sqrt{n}}\sqrt{\frac{q}{p}}$ and if p were constant would vary as the inverse square root of the number of cells in the length measured, or, on the assumption that cells are of the same size, inversely as the square roots of the lengths of the characters. This again does not fit our data, although it is very roughly true that the greater the lengths the smaller are the coefficients of variation. It appears therefore *a posteriori* as well as *a priori* probable that length characters are not capable, even roughly, of being treated in the matter of variation as built up of a number of equal sized cells, and that the differences between two individuals may depend not only on the number of cells, but on difference in the size of the cells. A most important investigation could be made by endeavouring to ascertain at an early stage of development the difference between individuals in the matter of size and number of cells forming a given character. But we do not think at present that any definite results as to these points can be made out from tabulated values of standard deviations and coefficients of variation. It is indeed as yet impossible to say how far higher values of the variation in small lengths may not be due to the increased proportional inaccuracy of reading such lengths, *i.e.* a ·3 mm. error made in reading the diameter of a femoral head is (roughly) ten times as important as in reading a femoral length.

(ii) *Comparative Racial Variability.*

We have very little here to go upon. Pearson and Lee have calculated the variability of the lengths of the chief long bones in Aino and French[2], and Warren provides the variability for three lengths, three angles and two indices

[1] Thorndyke (see *Mental and Social Measurements*, p. 133) without any reference to cells or without giving any valid reason has suggested as a coefficient of variation the standard deviation divided by the square root of the mean. The fallacy of such a measure of variation is seen at once when we consider that it depends on the scale on which measurements are read, and it would be impossible to compare the variability of a character which had to be read in microns with one which had to be read in centimetres.

[2] Bibl. 76 *bis*.

of the femur in the case of the Naqada Egyptian material[1]. The capito-collar length variability is also provided by Pearson and Lee. With the exception of Warren not a single writer on the femur has calculated the variability of its characters. This, owing to paucity of material, would be impossible in the cases of Lehmann-Nitzsche, Martin and Mollison. Something might have been done for Schwerz's material had he provided the individual measurements as he had considerable numbers. Parsons gives not a single measure of variability although his numbers justify it. As, however, so few of his measurements are comparable with ours, we have not spent our limited energies in reducing his data except in a few isolated cases. Koganei's numbers for Aino and Japanese are slender, and his platymeric measurements and capito-collar lengths not fully comparable with ours, but possibly his trochanteric length, his bicondylar width and his pilastric measurements are worth consideration. Hepburn's data[2] for modern British femora fall into the same class. Evangeli-Tramond's material is still more slender, *i.e.* 30 of each side and sex, and as there was considerable difficulty about a number of his indices arising from misprints and interchanges of columns in his tables, we gave up regretfully after trial the calculation of his variabilities.

We will now consider the available material and the inferences to be drawn from it.

Maximum Length.

Race	S.D.				C. of V.			
	♂		♀		♂		♀	
	No.	Value	No.	Value	No.	Value	No.	Value
Aino (R. + L.)	44	16·12	25	15·89	44	3·95	25	4·16
Naqada (R.)	80	25·19	113	20·75	80	5·48	113	4·87
Rothwell 'Medieval' (mean, R. and L.)	89*	19·34	52*	20·92	89	4·22	52	5·00
London, 17th century (mean, R. and L.)	221†	22·29	176†	20·58	221	4·97	176	5·03
French (R. + L.)	50	23·72	50	22·55	50	5·43	50	5·43

* See note as to London material which holds for Rothwell also.

† Throughout these tables the mean of the total numbers on R. and L. sides has been given in these columns for the London material. The results therefore are based on *twice* the number of femora recorded.

Trochanteric Length.

Race	S.D.				C. of V.			
	♂		♀		♂		♀	
	No.	Value	No.	Value	No.	Value	No.	Value
Aino (R. + L.)	41	17·89	25	15·78	41	4·58	25	4·32
London, 17th century (mean, R. and L.)	198	21·00	153	19·34	198	4·93	153	4·97

[1] Bibl. 77.

[2] Hepburn's anomalous femur *P* is omitted.

Oblique Length.

Race	S.D.				C. of V.			
	♂		♀		♂		♀	
	No.	Value	No.	Value	No.	Value	No.	Value
Naqada (R.)	80	24·93	113	20·83	80	5·47	113	4·93
Rothwell, 'Medieval' (mean, R. and L.)	86	19·24	52	19·93	86	4·23	52	4·79
London, 17th century (mean, R. and L.)	208	21·90	165	20·52	208	4·92	165	5·06
Modern British (R. + L.)	42	17·85	—	—	42	3·89	—	—

Capito-Collar Length.

Race	S.D.				C. of V.			
	♂		♀		♂		♀	
	No.	Value	No.	Value	No.	Value	No.	Value
Aino (R. + L.)...	42	3·93	24	2·69	42	5·79	24	4·34
Naqada (R.)	43	4·94	61	4·50	43	6·90	61	6·91
London, 17th century (mean, R. and L.)	228	7·00	175	6·29	228	9·08	175	9·26

Bicondylar Width.

Race	S.D.				C. of V.			
	♂		♀		♂		♀	
	No.	Value	No.	Value	No.	Value	No.	Value
Aino	36	3·21	22	2·48	36	4·08	22	3·47
[Rothwell*, 'Medieval' (mean, R. and L.)	80	3·63	45	2·67	80	4·73	45	3·94]
London, 17th century (mean, R. and L.)	158	4·07	108	3·43	158	5·10	108	4·89
Modern British (R. + L.)	35	6·38	—	—	35	7·66	—	—

* Width of articulation of distal epiphysis.

Koganei has unfortunately not taken the diameters of his femoral head. Parsons has taken the projection of the diameter of the head on a plane perpendicular to the axis of the neck, which besides giving a measurement incomparable with ours is open in the case of variation to the error of setting the bars of the callipers "parallel to the long axis of the neck." We can therefore only legitimately compare our results with Hepburn's.

Diameter of Head.

Race	S.D.				C. of V.			
	♂		♀		♂		♀	
	No.	Value	No.	Value	No.	Value	No.	Value
[Rothwell, 'Medieval' (mean, R. and L.)	87	2·36	53	1·94	87	4·80	53	4·58]
London, 17th century (mean, R. and L.)	208	2·84	159	2·04	208	6·06	159	4·98
Modern British (R. + L.)	39	4·79	—	—	39	10·07	—	—
Modern American, with cartilages ...	200	2·67	200	2·63	200	5·37	200	6·00

For the platymeric diameters comparison is less legitimate because of differences in the manner of measuring. We find however:

Platymeric Diameters.

Race	Antero-Posterior Direct								Transverse							
	S.D.				C. of V.				S.D.				C. of V.			
	♂		♀		♂		♀		♂		♀		♂		♀	
	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value
Aino (R.+L.)	47	1·99	20	1·49	47	8·37	20	6·99	47	1·93	20	1·80	47	5·98	20	5·97
Rothwell, 'Medieval' (mean, R.&L.)	92	2·07	54	1·69	92	7·14	54	6·66	92	2·66	54	2·70	92	7·03	54	7·53
London, 17th cent. (mean, R. & L.)	242	1·95	186	1·70	242	7·28	186	7·19	242	2·85	186	2·42	242	9·03	186	8·46
Modern British (R.+L.)	43	2·79	—	—	43	10·48	—	—	43	2·97	—	—	43	9·31	—	—

We next turn to the pilastric diameters and obtain the following results:

Pilastric Diameters.

Race	Antero-Posterior								Transverse							
	S.D.				C. of V.				S.D.				C. of V.			
	♂		♀		♂		♀		♂		♀		♂		♀	
	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value
Aino (R.+L.)	46	2·30	20	2·20	46	8·29	20	8·93	46	1·77	20	1·39	46	6·65	20	5·70
Rothwell, 'Medieval' (mean, R.&L.)	92	2·37	34	2·24	92	7·43	54	8·09	—	—	—	—	—	—	—	—
London, 17th cent. (mean, R. & L.)	244	2·35	191	2·07	244	8·07	191	8·12	244	2·12	191	1·99	244	7·57	191	7·87
Modern British (R.+L.)	43	2 97	—	—	43	9·93	—	—	43	2·58	—	—	43	9·42	—	—

Such is all the material we can exhibit for variation of the absolute lengths. We have ten characters or twenty coefficients in all if we note that there are results for the two sexes. If we compare the Aino and our London femora, we have sixteen coefficients for comparison, and of these thirteen are greater in the London femur. The three cases in which the Aino femur is more variable are the direct platymeric antero-posterior diameter in males and the pilastric antero-posterior diameter in both males and females, but it is doubtful if any stress can be laid on these exceptions, at any rate as compared with remarkable difference in variability of both platymeric and pilastric transverse diameters. A comparison of the six coefficients available in the case of Naqada and London femora, show four in excess in the London femora. But the material is too small for a judgment of any value.

If we consider the matter in relation to sex we have for eight characters in the coefficient of variations:

Mean London Male coefficient = 7·00,
Mean London Female coefficient = 6·97.

In five the female is in excess, in three the male.

Mean Aino Male coefficient = 6·07,
Mean Aino Female coefficient = 5·48.

In two the female is in excess in eight the male.

These results appear to be generally in accordance with those reached by Pearson and Lee in 1897, namely that the primitive race is less variable than the civilised race, and that with civilisation woman tends to gain in variability on man. Such results would flow from the selection becoming less intense for women as civilisation advanced[1].

We now turn to such angular variabilities as are available for comparison. Here we have no Aino material to help us out, nor does Hepburn provide anything. We are therefore forced to confine our attention to the comparison of Naqada and London English. We take first the cervical or collar angle.

Cervical or Collar Angle.

Race	S.D.				C. of V.			
	♂		♀		♂		♀	
	No.	Value	No.	Value	No.	Value	No.	Value
Naqada (R.)	45	5°·58	88	6°·08	45	4·47	88	4·79
Rothwell, 'Medieval' (mean, R. and L.)	92	5°·40	53	4°·16	92	4·28	53	3·32
London, 17th century (mean, R. and L.)	228	6°·60	175	7°·26	228	5·04	175	5·59

We take next the obliquity[2].

Obliquity.

Race	S.D.				C. of V.			
	♂		♀		♂		♀	
	No.	Value	No.	Value	No.	Value	No.	Value
Naqada (R.)	80	2°·06	113	2°·32	80	35·66	113	32·08
Rothwell, 'Medieval' (mean, R. and L.)	84	1°·93	50	2°·19	84	20·51	50	20·64
London, 17th century (mean, R. and L.)	226	1°·95	171	2°·02	226	19·77	171	19·40

No stress can here be laid on the apparently greater variability of the Naqada femora, for Warren is not measuring the true obliquity, and further the right member for both sexes has a less obliquity and a greater variation[3]. However

[1] It may of course be doubted whether we have got the full variability of the women for in our plague pit material there are more men roughly than women by a third. There has thus been ante-mortem (departure from London to escape the plague) or post-mortem (destruction of less stout bones) selection of female bones, and of course the Aino bones may have been still more stringently selected. This question of selection is too often disregarded. We have shewn, indeed, in Chapter III (p. 151, ftn.) that a selection of upwards of 30 °/₀ may not largely disturb mean and standard deviation. But when material is used where there are *four times the number of males that there are females*, we must seriously question either the sexing or the suitability of the material for testing variation, especially when the male material is found almost invariably greater in variability than the female. This aspect of the problem does not seem to have occurred to Dr Young in his discussion of variability in his recent and in many respects admirable memoir on the Scottish skull (*Trans. R. S. Edinburgh*, Vol. LI, 1916, pp. 347 *et seq.*): see especially p. 389.

[2] For the Naqada femora Warren only gives the pseudo-obliquity: see our p. 31.

[3] London R. bones give 2°·02, 2°·14, 23·23, 22·73 respectively for ♂ and ♀ S.D.'s and C. of V.'s.

for London R. bones there is sensibly no difference in the variation of the obliquity as measured by the standard deviations from the pseudo-obliquity variation of the Naqada bones.

Lastly we take the torsion measured in the Naqada case by a somewhat different procedure, which, we believe tends to exaggerate the torsion.

Torsion.

Race	S.D.				C. of V.			
	♂		♀		♂		♀	
	No.	Value	No.	Value	No.	Value	No.	Value
Naqada (R.)	45	8°·07	87	7°·78	45	37·12	87	29·80
Rothwell, 'Medieval' (mean, R. and L.)	83	8°·42	50	9°·44	83	63·84	50	56·24
London, 17th century (mean, R. and L.)	205	8°·99	157	9°·95	205	69·05	157	62·87

Judging by the standard deviations of all three angles the females are more variable than the males in the more modern (London) bones; they are more variable than the male in two out of the three angles in the ancient (Aino) bones, but the variation differences in the more reliable measurements, the collar and torsional angles, are less in the ancient bones. In our opinion the high coefficients of variation in the obliquity and torsion are of no significance, any more than the low coefficients in the case of the collar angle. If the collar angle and obliquity had been measured from the horizontal instead of the vertical, the relative coefficients of variation would have been just reversed! Such coefficients are in the cases of angles of a wholly artificial character.

We now turn to the few indices of which we have knowledge of comparative variation. Warren unfortunately does not give pilastric or platymeric measurements, but provides the bust-ratio and the bust-shaft index. Unluckily his determination of the capito-collar axis is by the appreciative fixing on anterior and posterior surfaces of the coaxial point, which we felt compelled to relinquish.

Primary Bust-Ratio (Capito-Collar Length/Maximum Length).

Race	S.D.				C. of V.			
	♂		♀		♂		♀	
	No.	Value	No.	Value	No.	Value	No.	Value
Naqada (R.)	45	·85	87	·72	45	5·35	87	4·67
London, 17th century (R.)	213	1·59	157	1·70	213	9·22	157	10·16

If we can trust the different methods of measurement to give reliable comparative results there is no doubt that the modern bones are much more variable than the ancient.

Turning now to the bust-shaft index we have:

Bust-Shaft Index (Capito-Collar Length/Shaft Length).

Race	S.D.				C. of V.			
	♂		♀		♂		♀	
	No.	Value	No.	Value	No.	Value	No.	Value
Naqada (R.)	45	1·06	87	·90	45	5·76	87	5·04
London, 17th century (R.)	227	2·18	167	2·41	227	10·71	167	12·16

Here again there is no doubt about the greater variability of the modern bones, provided we are justified in comparing results reached by the two processes.

Some light may be thrown on this point by giving our results for the capito-collar and shaft lengths as found by Warren's process and our own finally adopted method; we did not, however, calculate the 800 indices by the old as well as the new method:

London Femora	Mean		S.D.		C. of V.	
	Warren's Process	Our Process	Warren's Process	Our Process	Warren's Process	Our Process
Capito-Collar Length ♂ R.	79·308 ± ·254	77·037 ± ·318	5·580 ± ·180	7·110 ± ·225	7·035 ± ·228	9·229 ± ·295
,, ,, ,, ♂ L.	79·747 ± ·233	77·212 ± ·307	5·251 ± ·165	6·884 ± ·217	6·584 ± ·208	8·916 ± ·283
,, ,, ,, ♀ R.	70·623 ± ·266	68·380 ± ·330	5·165 ± ·188	6·331 ± ·234	7·314 ± ·268	9·259 ± ·345
,, ,, ,, ♀ L.	70·842 ± ·217	67·396 ± ·312	4·368 ± ·154	6·240 ± ·221	6·166 ± ·218	9·259 ± ·330
Shaft Length ♂ R. ...	382·413 ± ·892	377·980 ± ·933	19·534 ± ·631	20·837 ± ·660	5·108 ± ·165	5·513 ± ·175
,, ,, ♂ L. ...	381·210 ± ·850	376·203 ± ·935	19·146 ± ·601	20·983 ± ·661	5·022 ± ·158	5·578 ± ·176
,, ,, ♀ R. ...	351·459 ± ·973	347·883 ± 1·072	18·855 ± ·688	20·539 ± ·758	5·365 ± ·196	5·904 ± ·219
,, ,, ♀ L. ...	350·152 ± ·964	347·604 ± 1·107	19·391 ± ·682	18·514 ± ·654	5·538 ± ·195	5·326 ± ·189

It will be seen that the result of our process has been to decrease the shaft length and also the capito-collar length, or in other words to bring the coaxial point toward the mesial side and so increase the collar angle. On the other hand our process shows slightly greater variation in the shaft length and much greater variation in the capito-collar length. It may be asked why, if the variations in our lengths are greater than those given by the process adopted by Warren we discarded the latter. The answer is that we believe that such an important character as the collar angle ought to be determined by a process which is purely mechanical and not open to personal equation in a marked manner. Warren's method leaves the determination of the axis of neck and shaft to *ocular* appreciation, and the result is that a certain form of triangle *CDO* is we believe liable to impress itself on the mind and prejudice us in favour of a more constant collar angle *CDO* than a purely mechanical process[1]. At the same time the

[1] Warren's description (Bibl. 77, p. 137) is rather vague; he does not say how "the central point (*C*) of the inner surface of the head" is to be determined, only that it is readily found. He does not define his point *D* which we take to be our *O*, the mid-trochlear point. Further he tells us that "if lines

difference in variability of the measurements obtained by the two processes renders it impossible for us to be very emphatic about the excess of variation in these two indices.

We can, however, approach the matter from another standpoint. The coefficient of variation v_i of an index $i = 100x/y$ is given in terms of the coefficients of variation of x and y by the approximate formula

$$v_i = \sqrt{v_x^2 + v_y^2 - 2v_x v_y r_{xy}},$$

where r_{xy} is the correlation of x and y.

Now we found, using Warren's process, that the correlations of capito-collar length with *oblique* length and shaft length in London material were:

	♂ R.	♂ L.	♀ R.	♀ L.
Capito-Collar Length and Maximum Length	+·578 ± ·032	+·467 ± ·037	+·319 ± ·049	+·319 ± ·047
Capito-Collar Length and Shaft Length ...	+·412 ± ·038	+·366 ± ·038	+·254 ± ·048	+·184 ± ·048

Now these values would certainly not be much modified if we had used maximum length instead of oblique length. Accordingly using the above formula we find for the coefficient of variation of the bust-ratio and bust-shaft index deduced for our London material by Warren's process:

	♂ R.	♂ L.	♀ R.	♀ L.
Bust-Ratio	5·815	6·120	7·325	6·658
Bust-Shaft Index ...	5·474	5·620	6·282	6·781

These variations, although not nearly as large as those found by our process, are still in excess of the Naqada values. Further while the female is here in excess of the male variability in every case, in the Naqada she was in defect. Thus we again confirm the views stated above as to primitive and more modern peoples.

We now turn to the last pair of indices for which we can make comparisons of variability, namely the platymeric and pilastric indices. The Aino results show some irregularity most probably owing to the paucity, especially of female, bones. But the prehistoric Alemanns of the Row-Graves demonstrate even with the heterogeneity due to mixed sexes that the more civilised race is substantially more variable.

be drawn parallel to the axes of the neck and shaft they will intersect at a point O," our coaxial point. But he does not tell us how to *draw* these lines, and it is a convention not a necessity that the axes of neck and shaft should pass through his C and D respectively. It seems to us that what he actually did was what we first did, mark by *ocular* appreciation the coaxial point on anterior and posterior surfaces, and then apply the calipers; we believe that this process leads the recorder to a more or less conventional triangle and so lessens the variability. Further the calipers' length is not in the plane of the collar axis, but is exaggerated and so *lessens* the collar angle.

Platymeric Index.

Race	S.D.				C. of V.			
	♂		♀		♂		♀	
	No.	Value	No.	Value	No.	Value	No.	Value
Aino (R. + L.)	47	6·88	20	4·86	47	9·34	20	6·84
Row-Grave Alemanns* (R. + L., ♂ + ♀)	970	6·73	970	6·73	970	8·42	970	8·42
Rothwell, 'Medieval' (mean, R. and L.)...	93	7·38	53	6·57	93	9·00	53	8·40
London, 17th century (mean, R. and L.)	242	9·06	186	9·29	242	10·63	186	10·72
Modern British (R. + L.)	43	8·91	—	—	43	10·58	—	—

Pilastric Index.

Race	S.D.				C. of V.			
	♂		♀		♂		♀	
	No.	Value	No.	Value	No.	Value	No.	Value
Aino (R. + L.)	46	8·81	20	10·24	46	8·42	20	10·12
Row-Grave Alemanns* (R. + L., ♂ + ♀)	970	7·10	970	7·10	970	6·70	970	6·70
London, 17th century (mean, R. and L.)	244	9·40	190	9·29	244	9·00	190	9·15
Modern British (R. + L.)	43	8·53	—	—	43	7·92	—	—

* We have calculated these results from the data given by Schwerz, Bibl. 107, S. 655, but the table given there is not self-consistent. Schwerz combines R. and L., ♂ and ♀ so that his total number is much exaggerated as compared with our 244. The comparison should be between 870 and 970 bones, roughly.

Thus the whole of the racial material we have been able to compare seems to confirm the view expressed in 1897 that in uncivilised races there is less variability than in civilised races, which we interpret to mean that the adult is kept closer to type by more stringent physical selection.

(iii) *Comparative Variability of Left and Right Side.*

We now turn to the comparative variability of right and left side. We have first to ascertain exactly, as in the previous chapter, which differences are significant. Since the absolute lengths for R. and L. are so closely in accordance it will be adequate to compare the standard deviations of right and left side and we need not consider their coefficients of variation. Further to bring out one or two points we shall keep the differences in the order of the fundamental classification.

The appearance of this table is remarkable; only one difference exceeds three times its probable error—the female popliteal antero-posterior direct diameter. And here the sign of the difference is reversed in the male bones. The excessive variability of this diameter in the female bones is to a large extent due to the presence of two outlyers in the R. bones which we have found no justification for rejecting. The reversal of sign in the male bones does not permit, however, of our asserting generally that the right bone is more variable than the left in popliteal antero-posterior direct diameter. For other characters we only reach *possible* significance in :

TABLE V. *Differences of Standard Deviations with Probable Errors.*

Character	Male		Female	
	$\Delta_{R.-L.} \pm e_\Delta$	$\frac{\Delta_{R.-L.}}{e_\Delta}$	$\Delta_{R.-L.} \pm e_\Delta$	$\frac{\Delta_{R.-L.}}{e_\Delta}$
Maximum Length	− ·034 ± 1·010	− ·03	− ·941 ± 1·047	− ·90
Trochanteric Length	− ·736 ± 1·008	− ·73	− ·434 ± 1·026	− ·42
Max. Trochanteric Length ...	− 1·113 ± 1·037	− 1·07	− ·925 ± 1·034	− ·89
Oblique Length	− ·455 ± 1·024	− ·44	− ·794 ± 1·030	− ·77
Trochanteric Oblique Length ...	− ·889 ± 1·049	− ·85	− ·204 ± 1·095	− ·19
Vert. Diam. of Head	+ ·090 ± ·133	+ ·68	+ ·077 ± ·110	+ ·70
Horiz. Diam. of Head	+ ·227 ± ·134	+ 1·69	+ ·047 ± ·113	+ ·42
Horiz. Diam. of Neck	+ ·159 ± ·094	+ 1·69	− ·061 ± ·090	− ·68
Vert. Diam. of Neck	+ ·060 ± ·119	+ ·50	+ ·017 ± ·101	+ ·17
Platymeric A. P. Diam.	− ·091 ± ·084	− 1·08	+ ·119 ± ·084	+ 1·42
Platymeric Trans. Diam.	+ ·187 ± ·124	+ 1·51	+ ·286 ± ·121	+ 2·36
Pilastric A. P. Diam.	− ·128 ± ·092	− 1·39	− ·093 ± ·101	− ·92
Pilastric Trans. Diam.	+ ·132 ± ·102	+ 1·29	− ·089 ± ·097	− ·92
Popliteal Length	+ 1·418 ± ·712	+ 1·99	− ·877 ± ·762	− 1·15
Popliteal Width	+ ·059 ± ·175	+ ·34	+ ·229 ± ·163	− 1·40
Popliteal Direct A. P. Diam. ...	− ·238 ± ·110	− 2·16	+ ·525 ± ·106	+ 4·95
Popliteal Oblique A. P. Diam. ...	− ·119 ± ·111	− 1·08	+ ·245 ± ·101	+ 2·43
Bicondylar Width	− ·084 ± ·217	− ·39	− ·065 ± ·222	− ·29
Max. Length, Ext. Condyle ...	+ ·066 ± ·152	+ ·43	+ ·169 ± ·150	+ 1·13
Max. Length, Int. Condyle ...	+ ·119 ± ·164	+ ·73	− ·087 ± ·158	− ·55
Oblique Length, Ext. Condyle ...	− ·043 ± ·145	− ·30	+ ·319 ± ·139	+ 2·29
Horiz. Band-radius, Ext. Condyle	+ ·107 ± ·097	+ 1·10	+ ·036 ± ·105	+ ·34
Vert. Band-radius, Ext. Condyle ...	+ ·066 ± ·090	+ ·73	+ ·058 ± ·098	+ ·59
Diaphysial Subtense	+ ·046 ± ·079	+ ·58	+ ·132 ± ·085	+ 1·55
Diaphysial Chord	+ ·011 ± ·843	+ ·01	+ ·060 ± ·919	+ ·07
Capito-Collar Length	+ ·226 ± ·313	+ ·72	+ ·091 ± ·322	+ ·28
Length of Shaft	− ·146 ± ·934	− ·16	+ 2·025 ± 1·001	+ 2·02
Capito-Trochlear Length	+ ·636 ± ·982	+ ·65	+ 1·094 ± 1·058	+ 1·03

Female platymeric transverse diameter (+2·36)—this is not supported by the male bones.

Female popliteal oblique antero-posterior diameter (+2·43)—this is reversed in the male bones.

Female oblique length of external condyle (+2·29)—this is reversed in the male bones.

Female length of shaft (+2·02)—this is again reversed in the case of the male bones.

We are therefore compelled to conclude that no conspicuous difference in the variability of the absolute lengths of right and left bones exists; we cannot assert that the one has been subjected to more markedly stringent selection in this respect

than the other. While it is not possible to assert of any individual measurement that either member is markedly more variable than the other, still the measurements taken as a whole do show slight preponderances. Thus the left limb is more variable than the right in all the major lengths of the bone: see first five entries of the table. Possibly an exception to this is the capito-trochlear length. On the other hand of the 46 cases of shorter or minor lengths 32 differences have the plus sign, or the right is more variable than the left member. Such an excess of plus numbers if right and left were equally variable would only occur on random selection about once in 250 trials. We think we are therefore justified in suggesting that the left bone is somewhat more variable in the major lengths and the right bone somewhat more variable in the minor lengths, but neither has marked variability preponderance in any individual character.

We now turn to the angular variabilities where in our opinion we must also deal with standard deviations. It will be seen that not one of the differences for the variability in the angles of the fundamental triangle is significant. Nor is the obliquity definitely more variable on the right, though there is some approach to possible significance in the female.

TABLE VI. *Difference in Variability with Side of Femoral Angles.*

Angle	Male		Female	
	$\Delta_{R.-L.} \pm e_\Delta$ in degrees	$\frac{\Delta_{R.-L.}}{e_\Delta}$	$\Delta_{R.-L.} \pm e_\Delta$ in degrees	$\frac{\Delta_{R.-L.}}{e_\Delta}$
Midtrochlear Angle	+ ·020 ± ·056	+ ·36	+ ·045 ± ·069	+ ·65
Angle at Centre of Head ...	+ ·136 ± ·248	+ ·55	− ·247 ± ·316	− ·78
Cervical or Collar Angle ...	+ ·173 ± ·295	+ ·59	− ·320 ± ·371	− ·86
Obliquity	+ ·128 ± ·088	+ 1·45	+ ·245 ± ·104	+ 2·36
Torsion (Sign regarded)	− ·378 ± ·424	− ·89	+ ·439 ± ·537	+ ·82
Torsion (Sign disregarded) ...	− ·610 ± ·397	− 1·53	− ·385 ± ·511	− ·75
Torsion of Shaft	− ·005 ± ·562	− ·01	+ ·954 ± ·652	+ 1·46
Retorsion	+ 2·155 ± ·473	+ 4·56	+ 2·242 ± ·495	+ 4·53

Again, while the torsional angles of the femur and its shaft show no significance and even predominance of opposite members for the two sexes, when sign is regarded as we believe it should be, the retorsion is most markedly significant. We conclude therefore that only for one angle is there substantial difference and accordingly we can assert that the right bone is definitely more variable in the extent to which head and neck are retorted into parallelism with the condylar axis. We should anticipate that this may be associated with greater variability in the extent of frontal aspect of the acetabulum on the right side, but we know of no observations recorded on this point.

We now come to the last series of characters, namely the indices, in which there may be possibility of right or left predominance in variability. The following table gives the chief results:

TABLE VII. *Difference of Variability (Standard Deviations) with Side of Femoral Indices.*

Class	Index	Male		Female		Index	Class
		$\Delta_{R.-L.} \pm e_\Delta$	$\frac{\Delta_{R.-L.}}{e_\Delta}$	$\Delta_{R.-L.} \pm e_\Delta$	$\frac{\Delta_{R.-L.}}{e_\Delta}$		
Probably Significant	Ellipticity of Neck	+ 1·026 ± ·243	+ 4·22	+ 2·110 ± ·599	+ 3·52	Epiphysial Ratio	Probably Significant
Possibly Significant	Secondary Index of Bowing	− ·830 ± ·312	− 2·66	− 1·412 ± ·443	− 3·19	Platymeric Index	
	Pyramidal Popliteal Index	+ ·457 ± ·201	+ 2·27	+ ·093 ± ·030	+ 3·10	Oblique Maximum Trochanteric Length	
	Bicondylar Trochanteric Ratio ...	− ·112 ± ·050	− 2·24	+ ·091 ± ·031	+ 2·94	Index of Sagittal Slenderness	Possibly Significant
Probably Insignificant	Condylar Lengths Index	+ ·336 ± ·184	+ 1·83	+ ·643 ± ·284	+ 2·26	Ellipticity of Neck	
	Robusticity of Femur	+ ·060 ± ·035	+ 1·71	+ ·205 ± ·092	+ 2·23	Ellipticity of Head	
	Band-radial Index	+ ·994 ± ·602	+ 1·65	− ·666 ± ·322	− 2·07	Index of Gracility (Lower)	
	Platymeric Index	− ·582 ± ·393	− 1·48	+ ·475 ± ·230	+ 2·07	Condylar Index	
	Oblique Maximum Trochanteric Index	+ ·030 ± ·021	+ 1·43	+ ·240 ± ·118	+ 2·03	Bust-Shaft Index	
	Primary Index of Bowing	+ ·039 ± ·030	+ 1·30	+ ·448 ± ·277	+ 1·97	Index of Gracility (Upper)	Probably Insignificant
	Ellipticity of Head	− ·113 ± ·093	− 1·22	− ·412 ± ·235	− 1·79	Pyramidal Popliteal Index	
	Index of Sagittal Slenderness ...	+ ·034 ± ·028	+ 1·21	+ ·267 ± ·160	+ 1·67	Capito-Bicondylar Ratio	
	Bicondylar Ratio	− ·053 ± ·046	− 1·15	+ ·088 ± ·062	+ 1·42	Bicondylar Ratio	
	Index of Popliteal Skewness	− ·185 ± ·165	− 1·12	+ ·034 ± ·024	+ 1·41	Oblique Maximum Lengths Index	
	Capito-Bicondylar Ratio	− ·136 ± ·130	− 1·05	+ ·087 ± ·065	+ 1·34	Bicondylar Trochanteric Ratio	
	Neck-Head Index	+ ·173 ± ·168	+ 1·03	+ ·043 ± ·035	+ 1·23	Primary Index of Bowing	
Certainly Insignificant	Soffit Index	− ·205 ± ·230	− ·89	− ·213 ± ·196	− 1·09	Neck Head Index	Certainly Insignificant
	Capital Ratio	− ·023 ± ·026	− ·88	− ·147 ± ·194	− ·76	Index of Popliteal Skewness	
	Index of Gracility (Upper)	+ ·184 ± ·236	+ ·78	− ·022 ± ·030	− ·73	Capital Ratio	
	Pilastric Index	+ ·269 ± ·406	+ ·66	− ·031 ± ·047	− ·66	Condylar Trochanteric Ratio	
	Primary Bust Ratio	− ·048 ± ·074	− ·65	+ ·029 ± ·045	+ ·64	Robusticity of Femur	
	Index of Transverse Slenderness ...	+ ·012 ± ·028	+ ·43	+ ·282 ± ·460	+ ·61	Secondary Index of Bowing	
	Head-Bust Ratio	+ ·109 ± ·261	+ ·42	− ·257 ± ·455	− ·56	Pilastric Index	
	Robusticity of Head	+ ·017 ± ·055	+ ·31	− ·092 ± ·242	− ·38	Condylar Lengths Index	
	Index of Gracility (Lower)	+ ·088 ± ·285	+ ·31	+ ·035 ± ·095	+ ·37	Secondary Bust Ratio	
	Secondary Bust Ratio	− ·022 ± ·075	− ·29	+ ·183 ± ·668	+ ·27	Band-radial Index	
	Epiphysial Ratio	− ·129 ± ·459	− ·28	− ·049 ± ·221	− ·22	Popliteal Shaft Index	
	Popliteal Index	− ·078 ± ·283	− ·20	+ ·014 ± ·063	+ ·22	Robusticity of Head	
	Bust-Shaft Index	+ ·018 ± ·097	+ ·19	− ·054 ± ·284	− ·19	Popliteal Index	
	Condylar-Trochanteric Ratio	+ ·005 ± ·033	+ ·15	− ·005 ± ·034	− ·15	Index of Transverse Slenderness	
	Oblique Maximum Lengths Index ...	+ ·001 ± ·020	+ ·05	− ·013 ± ·091	− ·14	Primary Bust Ratio	
	Condylar Index	+ ·001 ± ·156	+ ·01	+ ·026 ± ·305	+ ·09	Head-Bust Ratio	
	Popliteal Shaft Ratio	− ·001 ± ·187	− ·01	− ·004 ± ·270	− ·01	Soffit Index	

Of the four characters which are probably or possibly significant in the male only one, the ellipticity of neck, appears possibly significant in the female. In both sexes the variability is greater in the right than the left member and it would appear to be a real difference. In the remaining three cases of possible male significance (Secondary Index of Bowing, Pyramidal Popliteal Index and Bicondylar Trochanteric Ratio) the female reverse the male results, besides giving values which are certainly or probably insignificant. Of the nine cases of probably or possibly significant female difference we have already considered the ellipticity of the neck; in three cases (Epiphysial Ratio, Ellipticity of Head and Index of Gracility (lower)) the male results besides being insignificant reverse the female; in two further cases (Condylar Index and Bust-Shaft Index) the values while only possibly significant in the female are definitely insignificant in the male; while in the remaining three cases (Platymeric Index, Oblique Maximum Trochanteric Lengths, and Index of Sagittal Slenderness) where the signs agree in both sexes and in the female the values are very likely significant, the values in the case of the male are probably insignificant. To sum up, while in these three last cases a longer series might possibly indicate a *slightly* differentiated variability in right and left members, we must assert that the ellipticity of the neck appears alone on our series to mark side differentiation; any other possible differentiations are screened by sexual differences and inadequacy of material.

As a general conclusion therefore we may state that neither right nor left member gives marked evidence of having been more stringently selected, *i.e* of being less variable than its fellow. The only two characters in which we have found significant differences are in the retorsion and the ellipticity of the neck. In both these cases the left bone is less variable than the right and it would appear accordingly to be a more intensely selected member[1] in these respects. The first character concerns the manner in which the neck and head are retorted to bring their axis again more nearly into the principal vertical plane, the second concerns the manner in which the shape of the collar section is modified. It is more than conceivable that the two characters are closely linked in their variation, the extent of the retorsion modifying the shape of the neck. This difference of

[1] The nature of this selection must be carefully borne in mind. Since every member of the community with no systematic exceptions ultimately passes through the graveyard, decreased variability in any character is not to be associated with ante-mortem stringent selection of the fitter. On the other hand if those possessed of extreme values of a character died young the lesser variability might be due to the post-mortem selection, which eliminates the youthful bones more extensively than the adult bones, or even due to the tabular selection which omits youthful and infantile bones from the record. In the case of plague pit material there would be ante-mortem selection due to the disease and due to the character of the inhabitants left behind to face the plague. It is of course possible but extremely unlikely that a disease like the plague could have any relation to differences of right and left members, or that the flight of the population from London would have any such relation. We should attribute any such differences as may be real to long-continued early selection of the race itself impressing its mark, perpetuated by inheritance on the left member. If we assume that differences in the left and right characters are due to this selection, it is not hard to grasp that differences in the variability will be due to the same action.

variability in right and left characters of the hip-joint we should be inclined to associate with ultimate organic differentiation of the two sides of the human body.

(iv) *Comparative Variability of the Sexes.*

Certain writers have assumed, and somewhat vigorously abused all those who differed from them, that the male is more variable than the female, and as far as we are aware they have asserted their point without any adequate system of measurements of male and female characters. A very long series of osteometric and especially cranial measurements have now convinced most biometricians that there is no significant general sexual difference in variability, although for a particular character one or other sex may be the more variable. This is not only true for the hundreds of continuous characters in man of which the variability has now been determined for both sexes, but also for the anomalies, especially the cranial anomalies, of the two sexes which have been recorded in great numbers. In dealing, however, with special series one has to be careful that no marked selection by sex has taken place. When a cranial series shows four times as many males as females, we naturally distrust all arguments based on it as to the relative variability of male and female,—nay even as to the relative value of male and female characters[1]. In the case of our present material where the ratio of male to female is roughly 5 to 4, this may be due to post-mortem selection of the more slender bones, or to the flight of a section of the female population from the stricken city. In either case the variability is likely to have been to some extent affected by the selection. This must be borne in mind in discussing our results. In dealing with sexual differences in variability we shall discuss the significance of differences between male and female coefficients of variation for the absolute lengths, and of differences in the standard deviations of the angles and indices; the grounds for the choice of these criteria have already been given. We will consider first the femoral angles. These are given in the manner with which the reader will now be familiar in the following table:

TABLE VIII. *Difference in Variability[2] with Sex of Femoral Angles.*

Angle	Right Side		Left Side	
	$\Delta_{\sigma-\varphi} \pm e_\Delta$	$\frac{\Delta_{\sigma-\varphi}}{e_\Delta}$	$\Delta_{\sigma-\varphi} \pm e_\Delta$	$\frac{\Delta_{\sigma-\varphi}}{e_\Delta}$
Midtrochlear Angle	− ·113 ± ·064	− 1·8	− ·088 ± 061	− 1·4
Angle at Centre of Head ...	− ·439 ± ·284	− 1·5	− ·822 ± ·283	− 2·9
Cervical or Collar Angle ...	− ·422 ± ·337	− 1·3	− ·915 ± ·333	− 2·7
Obliquity	− ·117 ± ·103	− 1·1	·000 ± ·091	0·0
Torsion (sign regarded)	− 1·365 ± ·494	− 2·8	− ·548 ± ·473	− 1·2
Torsion (sign disregarded) ...	− 1·172 ± ·453	− 2·6	− ·947 ± ·462	− 2·0
Torsion of Shaft	− ·529 ± ·631	− 0·8	+ ·430 ± ·586	+ 0·7
Retorsion	+ ·907 ± ·543	+ 1·7	+ ·994 ± ·416	+ 2·4

[1] See our p. 170, ftn.

[2] Measured by standard deviation.

Now with the exception of the torsion of the shaft where the male and female differences are entirely insignificant the signs of the right and left side are in accordance throughout. We note at once that the female has excess of variability in twelve of the sixteen values given and the male only in three, while in one case there is equality. It would thus appear that the female is more variable than the male in the femoral angles[1]. We do not attribute this greater general variability to "inherent" greater variability in the female (as some authors have done for like cases in the male), but simply to the fact that in modern civilised peoples, we believe that for many generations there has been more stringent selection of the male. When we come to individual characters, however, none of the differences reach to probable significance, all are of the order of possible significance, the possibility being to some extent confirmed by common sign in the two members, and confused by sexual differentiation in the two members. On the whole it seems probable that woman is more variable in torsion and the collar angle, while the man is more variable in retorsion.

In Table IX on p. 181 the differences of the male and female standard deviations of the indices are given with the probable errors of those differences. Looking first at the signs of the differences we find that in 43 of the 66 values recorded the sign is minus or the female is more variable : in 22 the male is more variable and in one there is a draw. The odds are much against this preponderance of female variability being due to random sampling[2]. Thus the indices confirm the angles in indicating greater female variability. But the angles and indices, unlike the absolute dimensions, are the characters least likely to have been subjected to post-mortem selection.

This table does not show in the individual indices marked differences. It is probable that the female is more variable than the male in the Secondary Index of Bowing, in the Oblique Maximum Trochanteric Lengths Index and in the Condylar Trochanteric Index, while in the Popliteal Index the male is probably more variable. It is possible but less probable that the female is more variable than the male in the Secondary Bust Ratio and the Condylar Index. And lastly it is conceivable but not probable that on larger numbers the female might prove to be more variable in the Robusticity of the Femur and the Condylar Lengths Index. In the Epiphysial Ratio, the Platymeric Index and the Pyramidal Popliteal Index, where possibly significant sexual differences are shown on right or left side, the sign is reversed on the other side.

We must thus conclude that there is no marked sexual difference in variability of the individual indices, but the general run of the differences and what significant differences in individual characters occur are in favour of the greater variability of the female.

[1] The odds against this excess of female variability are about 82 to 1, and therefore it can hardly be a result of random sampling.

[2] Actually such excess of female variability would only occur once in 143 trials on the basis that its origin lies in random sampling.

TABLE IX. *Difference in Variability (Standard Deviations) with Sex of Femoral Indices.*

Class	Index	Right Side			Left Side			Index
		$\Delta_{\sigma-\varphi} \pm e_\Delta$	$\frac{\Delta_{\sigma-\varphi}}{e_\Delta}$	L. Side Rank	$\Delta_{\sigma-\varphi} \pm e_\Delta$	$\frac{\Delta_{\sigma-\varphi}}{e_\Delta}$	R. Side Rank	
Probably Significant	Secondary Index of Bowing ...	−2·533 ± ·398	−6·4	(1) 2	+ ·421 ± ·089	+4·7	(1) 18	Ellipticity of Head
	Obl. Max. Troch. Lengths Index	− ·130 ± ·028	−4·6	(2) 6	−1·421 ± ·388	−3·7	(2) 1	Secondary Index of Bowing
	Condylar Index	− ·781 ± ·210	−3·7	(3) 11	− ·139 ± ·040	−3·5	(3) 6	Condylar Troch. Index
	—	—	—	—	− ·668 ± ·210	−3·2	(4) 21	Condylar Lengths Index
Possibly Significant	Bicondylar Ratio	− ·157 ± ·057	−2·8	(4) 24	+1·153 ± ·399	+2·9	(5) 13	Platymeric Index
	Bicondylar Troch Ratio ...	− ·159 ± ·059	−2·7	(5) 26	− ·067 ± ·024	−2·8	(6) 2	Obl. Max. Troch. Lengths Index
	Condylar Troch. Index ...	− ·103 ± ·040	−2·6	(6) 3	− ·578 ± ·217	−2·7	(7) 16	Pyramidal Popl. Index
	Epiphysial Ratio	−1·497 ± ·580	−2·6	(7) 13	− ·097 ± ·039	−2·5	(8) 14	Robusticity of Femur
	Oblique Max. Lengths Index...	− ·053 ± ·023	−2·3	(9) 9	+ ·676 ± ·283	+2·4	(9) 9	Popliteal Index
	Popliteal Index	+ ·652 ± ·284	+2·3	(10) 22	+ ·060 ± ·028	+2·1	(10) 32	Index of Sagittal Slenderness
	Band-radial Index	+1·379 ± ·660	+2·1	(11) 14	—	—	—	—
	Secondary Bust Ratio ...	− ·173 ± ·087	−2·0	(12) 33	—	—	—	—
	Bust-Shaft Index	− ·223 ± ·113	−2·0	(8) 20	—	—	—	—
Probably Insignificant	Platymeric Index	− ·841 ± ·437	−1·9	(13) 13	− ·351 ± ·183	−1·9	(11) 3	Condylar Index
	Robusticity of Femur... ...	− ·066 ± ·042	−1·6	(14) 8	+ ·231 ± ·139	+1·7	(12) 19	Capito-Bicondylar Ratio
	Index of Gracility (Lower) ...	+ ·403 ± ·298	+1·4	(15) 18	+ ·742 ± ·484	+1·5	(13) 7	Epiphysial Ratio
	Pyramidal Popl. Index ...	+ ·291 ± ·220	+1·3	(16) 7	− ·116 ± ·084	−1·4	(14) 11	Secondary Bust Ratio
	Primary Bust Ratio	− ·111 ± ·083	−1·3	(17) 23	− ·307 ± ·237	−1·3	(15) 29	Ellipticity of Neck
	Ellipticity of Head	+ ·103 ± ·097	+1·1	(18) 1	− ·240 ± ·178	−1·3	(16) 23	Neck-Head Index
	Capito-Bicondylar Ratio ...	− ·172 ± ·152	−1·1	(19) 12	− ·038 ± ·031	−1·2	(17) 26	Index of Trans. Slenderness
	Index of Popl. Skewness ...	− ·188 ± ·177	−1·1	(20) 24	− ·351 ± ·310	−1·1	(18) 15	Index of Gracility (Lower)
	Condylar Lengths Index ...	− ·240 ± ·219	−1·1	(21) 4	+ ·275 ± ·247	+1·1	(19) 30	Soffit Index
	Index of Gracility (Upper) ...	− ·276 ± ·269	−1·0	(22) 27	− ·020 ± ·021	−1·0	(20) 8	Oblique Max. Lengths Index
Certainly Insignificant	Neck-Head Index	+ ·146 ± ·187	+0·8	(23) 16	− ·190 ± ·203	−0·9	(21) 27	Popliteal Shaft Index
	Pilastric Index	+ ·366 ± ·437	+0·8	(24) 30	+ ·568 ± ·610	+0·9	(22) 10	Band-radial Index
	Robusticity of Head	+ ·042 ± ·062	+0·7	(25) 25	− ·076 ± ·082	−0·9	(23) 17	Primary Bust Ratio
	Index of Trans. Slenderness ...	− ·021 ± ·033	−0·6	(26) 17	− ·150 ± ·183	−0·8	(24) 20	Index of Popl. Skewness
	Popliteal Shaft Index ...	− ·142 ± ·206	−0·6	(27) 21	+ ·039 ± ·057	+0·7	(25) 25	Robusticity of Head
	Primary Index of Bowing ...	− ·017 ± ·034	−0·5	(28) 29	+ ·040 ± ·056	+0·7	(26) 5	Bicondylar Troch. Ratio
	Ellipticity of Neck	+ ·076 ± ·288	+0·3	(29) 15	− ·012 ± ·245	−0·5	(27) 22	Index of Gracility (Upper)
	Soffit Index	+ ·074 ± ·254	+0·3	(30) 19	− ·126 ± ·277	−0·5	(28) 31	Head-Bust Ratio
	Head-Bust Ratio	− ·045 ± ·290	−0·2	(31) 28	− ·013 ± ·031	−0·4	(29) 28	Primary Index of Bowing
	Index of Sagittal Slenderness	+ ·003 ± ·031	+0·1	(32) 10	− ·160 ± ·426	−0·4	(30) 24	Pilastric Index
	Capital Ratio	·000 ± ·028	0·0	(33) 32	− ·016 ± ·052	−0·3	(31) 4	Bicondylar Ratio
	—	—	—	—	+ ·001 ± ·028	+0·0	(32) 33	Capital Ratio
	—	—	—	—	− ·001 ± ·103	−0·0	(33) 12	Bust-Shaft Index

In Table X will be found the differences of the coefficients of variability of the absolute lengths with their probable errors in the case of the two sexes. If we consider merely the signs of the differences there are 30 of the 56 values greater for the male and 26 greater for the female, or since the half would be 28, we have a transfer of 2 to the male side, a difference well within the limits of random sampling. But a little

TABLE X. *Sexual Differences of Coefficients of Variation of the Absolute Femoral Lengths.*

Measurement	Right Side			Left Side		
	$\Delta_{\sigma-\varphi} \pm e_\Delta$	$\frac{\Delta_{\sigma-\varphi}}{e_\Delta}$	Rank	$\Delta_{\sigma-\varphi} \pm e_\Delta$	$\frac{\Delta_{\sigma-\varphi}}{e_\Delta}$	Rank
Maximum Length	+ ·080 ± ·195	+ ·41	20	− ·198 ± ·242	− ·82	15
Trochanteric Length	− ·065 ± ·258	− ·25	23	− ·013 ± ·252	− ·05	27
Max. Troch. Length	− ·007 ± ·258	− ·03	28	+ ·033 ± ·255	+ ·01	28
Oblique Length	− ·072 ± ·249	− ·29	22	− ·193 ± ·250	− ·77	18
Troch. Oblique Length	− ·136 ± ·271	− ·50	18	+ ·026 ± ·264	+ ·10	25
Vert. Diam. of Head	+ 1·083 ± ·285	+ 3·80	1	+ ·928 ± ·268	+ 3·46	4
Horiz. Diam. of Head	+ 1·055 ± ·298	+ 3·54	2	+ ·685 ± ·269	+ 2·55	7
Horiz. Diam. of Neck	+ 1·047 ± ·392	+ 2·67	4	+ ·106 ± ·372	+ ·28	24
Vert. Diam. of Neck	+ 1·215 ± ·359	+ 3·38	3	+ 1·040 ± ·336	+ 3·10	5
Platymeric A. P. Diam.	− ·281 ± ·345	− ·81	13	+ ·465 ± ·332	+ 1·40	12
Platymeric Trans. Diam.	+ ·323 ± ·435	+ ·74	15	+ ·805 ± ·384	+ 2·10	9
Pilastric A. P. Diam.	− ·056 ± ·366	− ·15	25	− ·022 ± ·385	− ·06	26
Pilastric Trans. Diam.	+ ·073 ± ·365	+ ·20	24	− ·680 ± ·354	− 1·92	10
Popliteal Length	+ ·572 ± ·658	+ ·87	12	− 1·735 ± ·633	− 2·74	6
Popliteal Breadth	+ ·585 ± ·460	+ 1·27	9	+ ·969 ± ·444	+ 2·18	8
Popliteal Direct A. P. Diam.	− 1·118 ± ·445	− 2·51	5	+ 2·031 ± ·396	+ 5·13	1
Popliteal Oblique A. P. Diam.	− ·049 ± ·380	− ·13	26	+ 1·295 ± ·364	+ 3·56	3
Bicondylar Width	+ ·183 ± ·300	+ ·61	17	+ ·227 ± ·294	+ ·77	17
Max. Length, Ext. Condyle	+ ·193 ± ·261	+ ·74	16	+ ·396 ± ·252	+ 1·57	11
Max. Length, Int. Condyle	+ ·530 ± ·289	+ 1·83	6	+ ·192 ± ·272	+ ·71	19
Oblique Length, Ext. Condyle	+ ·203 ± ·250	+ ·81	14	+ ·863 ± ·235	+ 3·67	2
Ext. Condyle, Horiz. Band-radius	+ ·242 ± ·601	+ ·40	21	− ·170 ± ·553	− ·31	23
Ext. Condyle, Vert. Band-radius	− ·221 ± ·501	− ·44	19	− ·233 ± ·475	− ·49	21
Diaphysial Subtense	− 2·673 ± 1·519	− 1·76	7	− ·831 ± 1·404	− ·59	20
Diaphysial Chord	− ·371 ± ·378	− ·98	10	− ·443 ± ·367	− 1·21	13
Capito-Collar Length	− ·030 ± ·454	− ·07	27	− ·343 ± ·435	− ·79	16
Length of Shaft	− ·391 ± ·252	− 1·55	8	+ ·252 ± ·258	+ ·98	14
Capito-Trochlear Length	− ·227 ± ·258	− ·88	11	− ·102 ± ·240	− ·43	22

closer inspection of the table indicates that if we omit the small epiphysial measurements—*i.e.* the second and sixth groups—there are only 13 male to 23 female preponderancies. In the proximal epiphysis *all* the differences are in favour of the male variability and in the distal epiphysis nine out of twelve values show male preponderance. We are compelled therefore to conclude either that the male is actually

more variable than the female or that the female has been far more intensely selected by post-mortem selection of the slighter bones. The latter is we believe the case for while we were able to measure the maximum length in 487 male and 381 female adult bones, we could only obtain femoral head measurements in 416 male and 319 female bones or reductions still further of 14·6 °/₀ and 19·4 °/₀: for the neck measurements the numbers are 460 and 350, showing 5·5 °/₀ and 8·1 °/₀ reductions respectively. Turning to the distal epiphysis the bicondylar width could only be found in 319 male and 216 female bones, or there was a still further selection of 34·5 °/₀ of male and 43·3 °/₀ of female bones. In other words when we come to take the epiphysial measurements we find the female has in every case been more heavily selected than the male. This corresponds with our experience of disinterred material; it is the epiphyses of the more slender bones which perish, in whole or part, first and accordingly the female suffers more than the male, and her epiphysial measurements are liable to be exaggerated and her variability reduced; thus her coefficients of variation on two counts are lessened. Any material in which the female appears in far lesser numbers than the male is open, therefore, to grave criticism when the absolute measurements are used to discuss relative sexual variability. The above table shows that in the diaphysis and even in the chief lengths of the femur (Group I, including also the capito-trochlear length) there is a general preponderancy of female variation. But we must not be content to dismiss the epiphyses with the admission of greater male variation possibly due to greater post-mortem female selection. We note that while the male preponderance in variation in the case of the distal epiphysis (9 to 3) has odds of about 23 to 1 against it on the basis of random sampling, there is only a single individual value which rises above 2 in the ratio of deviation to its probable error, namely the left oblique length external condyle, where it is 3·67, and only two cases where it even rises above unity, namely the left maximum length of external condyle with 1·57 and the right maximum length of internal condyle with 1·83. Thus the predominance of male variability is only really significant in one individual case, though the general run of positive signs confirms it. We believe that this preponderance might well be due to post-mortem selection of the stronger and stouter female bones for preservation. But the case is otherwise with the proximal epiphysis; of the eight values the male excess in variation is more than three times its probable error in five cases, and more than 2·5 times its error in two other cases: in only one case is it although positive insignificant. We are compelled to the conclusion that the male variability in the proximal epiphysis—although this shows less post-mortem selection than the distal epiphysis—is very considerably in excess of the latter. We believe that apart from post-mortem selection there is substantially less female variability in the proximal epiphysis than in the male. Turning back to Table VIII, we see that the Retorsion, again a character of the bust of the femur, appears also less variable in the female than in the male. Now we have already drawn attention to the more frontal aspect of the female pelvis involving a greater retorsion in the male, and we consider that the importance of a good attitude

of the pelvis in view of the burden of pregnancy has enforced more stringent conditions on the bust of the female pelvis, in other words from a very distant past there has in the case of the female been a more stringent selection of the proximal epiphysis. Hence the apparently greater variability of the male in this character.

If we look at the individual values in the groups of Table X we see that:

(i) In the first group of the principal lengths not a single case reaches once the probable error of the differences, and not one has even the suggestion of possible significance.

(ii) The same may be said of the sides of the fundamental triangle. Only one difference is more than once its probable error, and this is less than twice, while the left side has opposite sign to the right.

(iii) No individual difference of variability rises to even probable significance in the diaphysial, the platymeric or the pilastric groups of measurements.

(iv) In the popliteal group five out of the eight differences exceed the double of their probable error. In three of these cases when in the left bone possible and even probable significance is reached, we find reversal of sign in the differences in the right bone. In the fourth case—the popliteal breadth—the signs are the same, but the multiples of the probable error $+1{\cdot}27$ on the right and $+2{\cdot}18$ on the left side are not such as to justify a statement of definite significance.

(v) In the condylar group only one difference is over twice its probable error, *i.e.* the oblique length of the external condyle on the left side, and this should certainly be significant with a ratio of $+3{\cdot}67$; but the right side shows only the ratio of $+{\cdot}83$ which sadly weakens the case for significance.

(vi) Only in the group of measurements of the head and neck can we assert, with the possible exception of the horizontal diameter of the neck, an all round significance and a greater variability in the male.

Thus to sum up this section it is not on the basis of the femur possible to record any marked general difference in the variability of the two sexes. If anything the female appears to have more frequently excess of variability. In the special case of the proximal epiphysis where the male variability does appear in excess, we believe it is due to a more stringent selection of the bust of the female femur in the early stages of human evolution and that this selection must be associated with the more frontal aspect of the acetabula, or with a position of the pelvis probably associated with a better carriage during pregnancy.

The result that the female is slightly more variable than the male in civilised races would be entirely in keeping with masses of data for other organs.

(v) *Variability of the Femur compared with that of other Parts of the Human Skeleton.*

Two interesting problems arise with regard to variability: (*a*) how far is the femur more or less variable than the other long bones? and (*b*) how far is the femur more or less variable than other parts of the human skeleton? A third

problem arises but there is no material worked up at present with which to answer it—we should like to know: (*c*) what is the relative variability of the femur in man and other animals? Indeed no large series of bones has been even measured in other animals. A better bit of research work than taking the chief femoral measurements on one to two hundred femora of each of the chief anthropoid apes could hardly be planned. There is enough material, if it were pooled, in the chief British and continental museums, but such measurements of the femora of apes as have been published give only a few characters in a very few individuals or merely the mean values of a very few characters not the individual values, and so permit of no calculation of variation[1].

(*a*) *Comparison of Femoral Variability with that of other Long Bones.* All we have in the way of comparative data are the coefficients of variation of the lengths of the chief long bones of the French and Aino as found by Pearson and Lee[2] and of the Naqada as found by Warren[3]. We give them for comparison in the table below.

TABLE XI. *Coefficients of Variation of the Chief Long Bones.*

Race.

Measurement	Aino		Naqada		Londoners of 17th century		Modern French	
	♂	♀	♂	♀	♂	♀	♂	♀
Femur, Maximum Length	4·66 ± ·34	4·17 ± ·40	5·48	4·87	4·97 ± ·16	5·03 ± ·18	5·43 ± ·35	5·43 ± ·37
,, Oblique Length	—	—	5·47	4·93	4·93 ± ·17	4·97 ± ·19	—	—
Tibia, Maximum Length	4·92 ± ·38	4·50 ± ·46	5·04	4·93	—	—	4·89 ± ·33	5·57 ± ·38
,, Centre to Centre*	4·97 ± ·38	5·29 ± ·52	4·90	5·08	—	—	—	—
Fibula, Maximum Length	4·77 ± ·40	5·17 ± ·55	4·28†	6·26	—	—	4·97 ± ·34	5·56 ± ·38
Humerus, Max. Length	4·55 ± ·32	4·48 ± ·42	5·22	5·01	5·22 ± ·19	4·91 ± ·21	4·66 ± ·31	5·12 ± ·35
,, Oblique Length	—	—	5·13	4·99	5·08 ± ·19	4·94 ± ·21	—	—
Radius, Maximum Length	4·88 ± ·38	4·79 ± ·47	5·02	4·58	—	—	4·80 ± ·32	5·10 ± ·34
,, Centre to Centre	4·92 ± ·38	4·97 ± ·48	5·19	4·82	—	—	—	—
Ulna, Maximum Length	4·51 ± ·35	5·09 ± ·53	5·59	5·54	—	—	5·03 ± ·34	4·97 ± ·34
Clavicle, Maximum Length	5·33 ± ·43	6·86 ± ·73	6·99	6·73	—	—	—	—

* From centre to centre of articular surfaces.

† Warren gives solely the mean 373·67 and for 23 ♂ fibulae only. We were able to take 51 male fibulae from his tables of measurements and find mean = 375·80, S.D. = 16·096 and C. of V. = 4·283.

Now this table—based except in the case of the Londoners on rather slender material—seems to show that for the chief long bones the coefficients of variation will lie between four and five—or the absolute variation in the length of a long bone is about 4 °/₀ to 5 °/₀ of that length. It would be difficult to assert that in the intensity of variations the femur is more or less variable than any other

[1] There are a few individuals published by Hepburn (Bibl. 71, p. 153), Bumüller (Bibl. 81, Tabelle II) and Bertaux (Bibl. 52, p. 87), but the numbers are quite insufficient even for mean values. Larger series are given by Rodriguez (Bibl. 101, *Chapitre premier*) but unfortunately without the individual values. Antony and Rivet (Bibl. 97) give actual measurements on short series. Klaatsch cites only values from Bumüller.

[2] Bibl. 76 *bis*, pp. 347 and 348.

[3] Bibl. 77, pp. 140, 141 and 150.

long bone. There does appear, however, to be some excess of variability in the clavicle, although this must wait for further measurements to be published before there can be any real certainty. Nor is it possible to assert that the proximal bone of any limb is more or less variable than the distal. As far as man is concerned we cannot suppose at present that in his evolution one long bone has been much more stringently selected than a second. Indeed if direct selection had been more stringent in any case, the high correlation between nearly all the long bones would have brought about an indirect selection reducing the variability of the other bones not directly selected.

(*b*) *Comparison with other parts of the Skeleton.* We may compare the variability of the femur with that of the small bones of the hand and with the results reached for the skull. We will take the latter first. The general run of coefficients of variation for absolute lengths on the human skull is from 3 to 5, but *small* lengths like orbital, nasal and palate measurements tend to have values from 5 to 8, and the coefficient of variation of the capacity reaches the higher level, say from 7 to 9[1], which is the general run also of mandible variation. No coefficient of variation of the femur falls between 3 and 4, but the short lengths with coefficients of variation of 6 and 9 correspond closely with the short lengths on the skull. One or two lengths, however, rise to higher values—in particular the popliteal length between 13 and 14, the horizontal band-radius between 9 and 10, and the diaphysial subtense even between 27 and 30. On the basis of these high values, it might be suggested that the skull has been on the whole more intensely selected than the femur, and we think this is so when we find the coefficient of the length of the skull very little over 3 and the breadth almost of the same order, while the horizontal circumference has a value well under 3 (2·3 to 2·9). But we do not think that the high values for one or two femoral characters alone mark the femur out as less stringently selected than the skull. Thus in the skull the coefficient of variation of the mesodacryal chord is 9 to 12, of the mesodacryal arc 13·5, of the simotic chord 17 to 30 and of the simotic subtense 18 to 40 according to race and sex[2]. Accordingly the femur has no monopoly of high variation! It may be said that these femoral characters with high variation are precisely those which it is hardest to determine accurately; and this is certainly so in the case of the popliteal length and the diaphysial subtense. To some extent the same remarks apply to the mesodacryal and simotic measurements on the skull. There is indeed a factor here which must be recognised, namely, the calipers or the tape are always liable to an error of reading and this error has very little correlation with the total length to be read; if its standard deviation be R, we should have for the V or coefficient of variation of any character

$$V = 100\sqrt{\sigma^2 + R^2}/m,$$

where m is the mean and σ the standard deviation of any character. Accordingly if

[1] See Fawcett, *Biometrika*, Vol. I, p. 438, Macdonell, *Ibid.* Vol. III, pp. 222 and 226, and Vol. V, pp. 92—93, and Benington, *Ibid.* Vol. VIII, pp. 298—299.

[2] See *Biometrika*, Vol. VIII, pp. 298—300 and p. 318.

the true coefficient of variation of every absolute length were the same we should have for simple measurements with the same instrument

$$R = \frac{m_1 m_2}{100}\sqrt{\frac{V_1^2 - V_2^2}{m_2^2 - m_1^2}},$$

the same for every pair of characters with means m_1, m_2, and apparent coefficients of variation V_1 and V_2.

Several conclusions can be drawn from this result. (a) Judged from Maximum Length and Vertical Diameter of Head in male right bones R would be about 1·7 mm. or in reading with the calipers the probable error would be about 1·1 mm. This appears to be far too large. Working from the vertical diameter of the head and the horizontal diameter of the neck for the male right bones we find $R = 1{\cdot}8$ mm. with the probable error of reading about 1·2 mm., not badly in keeping with the previous value, but again apparently much too large. But when we take the platymeric and pilastric transverse diameters the latter (29·534 mm.) for male right bones is less than the platymeric transverse (31·678 mm.) but its coefficient of variation (9·791) is less than that of the latter (9·299) and accordingly R is imaginary. Again the capito-collar length is less than the popliteal length, but its coefficient of variation is also less and R is again imaginary. Again, if we take the bicondylar width and the maximum length of the external condyle for right male bones—both rather difficult measurements and suggesting a high rate of error—we find R only 0·5 mm. which might in this case be a reasonable value of the reading error but is wholly different from the excessive reading error which the theory suggests for the simpler measurements. Fascinating as the idea may be that true variation is largely physiological and proportional to the length measured, and that the actual coefficient of variation is constant and only disturbed by errors of reading, we cannot on the present data think it supported. Some differences of variation are certainly due to (i) physiological causes—in the roughest manner larger absolute lengths have smaller variation and (ii) to differences of accuracy in reading certain characters—such for example as the lengths of the nasal bridge, the band-radii or the popliteal length. Hence we must be cautious about drawing too fine distinctions from differences in coefficients of variation. But we must bear in mind an important point; it is more than conceivable that in the struggle for existence the larger measurements are or have been of much more importance for survival than the smaller dimensions. The size of a man's skull may be of more importance than the exact positions of his dacrya, or the total length of his femur more important than the breadth of it at the pilastric section. Thus it is possible, we do not say yet demonstrable, that great differences in variability are really marks of the stringency of past selection. Assuming this to be so we should have to conclude that generally, although not in all characters, the skull has been more stringently selected than the femur. A comparison of the femora of *Pithecanthropus*, the orang or even the chimpanzee, and again of the crania of these three with

the femur and skull of man seems to indicate that the differentiation has been far greater in the case of the skull. We might thus anticipate that the greater differentiation marks more stringent selection from the original common type, and that this stringency will be detectable in the existing coefficients of variation for the two organs[1].

We will next compare the absolute measurements of the bones of the hand with the femoral lengths in respect of variability. The only available data known to us are those published by Lewenz and Whiteley (*Biometrika* Vol. I, pp. 346–350) and based on Pfitzner's measurements. They deal with the variation of the metacarpal bone, the proximal phalanx, the middle phalanx and the distal phalanx of all ten fingers. The values of the coefficients of variation range from 5·12 to 8·95[2], say from five to nine; the least variable being the metacarpal bone of the left middle finger and the most variable the middle phalanx of the right little finger. On the average of all bones of the finger the index finger of the right hand is least and the little finger most variable (4·90 and 6·10). On the average of all fingers the middle phalanx of both hands is most variable and the metacarpal bone of both hands least variable (7·20 to 5·7 about). Thus we see that the femora in its chief length is less variable than the bones of the hand, but in its small lengths is probably more variable, but as no transverse diameters of the hand bones were taken comparison is not really possible. The hand, however, does not show signs of *markedly* more stringent selection than the femur.

We now turn to the indicial variability and we find that for the indices of the principal lengths of the skull (maximum length, maximum breadth and height) the *standard deviations* run from just under three to just over five. We can hardly compare with these the Oblique Maximum Lengths Index or the Oblique Maximum Trochanteric Index of the femur, because the latter have so much in common of the components of the ratios. We might better compare the Primary and Secondary Bust Ratios, the Bust-Shaft Ratio, the Bicondylar Ratio, the Bicondylar Trochanteric Ratio and the Condylar Trochanteric Ratio. In many of these cases the standard deviation of the index is less than unity and in none greater than a slight excess over two, and we should be compelled to say that the femur in the ratio of its parts has been more stringently selected than the skull[3]. This suggests, but does not demonstrate, that the correlation of the

[1] There is an immense amount of biometric work waiting to be done in this direction when material and workers are forthcoming. Take the characters of the nasal bridge in man, the anthropoidal apes or a gazehound and let their variabilities be compared with those of the nasal characters in any sleuth-hound or in a pointer breed, or compare the differences between nasal characters in fox or wolf with those of domesticated animals like sheep or swine, and we should soon learn how far variation somewhat contemptuously and without any real investigation of value described as "fluctuating" by the Mendelians are real measures of the stringency of past selection.

[2] *Loc. cit.* p. 347.

[3] If we judge by the coefficients of variation not the standard deviations of the indices, the Bicondylar Ratio, the Bicondylar Trochanteric Ratio and the Condylar Trochanteric Ratio have about the same order of variation as the chief cephalic indices, but the Bust-Shaft and the Bust-Ratios have coefficients of variation *twice* those of the cephalic indices and would therefore have to be considered as more rather

components of these indices in the femur will be found more highly correlated than the components of the indices in the case of the skull. If we take the indices for the ratio of small measurements on the skull such as the orbital, palatal, nasal and perhaps facial indices, we may possibly also add the mesodacryal and simotic indices (*Biometrika*, Vol. VII, p. 318), their *standard deviations* range from about four to twelve and compare fairly with the Head-Bust Ratio, the Neck-Head Index, the two Indices of Gracility, the five Popliteal Indices ((*r*), (*ll*), (*cc*), (*bb*) and (*yy*): see Table II), the Platymeric, the Pilastric Indices, the Ellipticity of the Neck, the Band-radial Index and the Epiphysial Ratio. On the other hand the Ellipticity of the Head, the Robusticity of the Head, the Robusticity of the Femur, the two Indices of Slenderness, the Condylar Index, the Capito-bicondylar Ratio and the Capital Ratio possess remarkably low standard deviations below any values yet met with in the case of the skull. They may, however, be separated into two classes, first the Robusticity of the Head, the Robusticity of the Femur, the two Indices of Slenderness and the Capital Ratio have low means, and accordingly their coefficients of variation run from five to eight and are comparable with the values for the coefficients of variations of skull indices of the nasal and palatal class. Secondly the Ellipticity of the Head, the Condylar Index and the Capito-bicondylar Ratio have high or fairly high mean ratios and their coefficients of variation should be comparable with the six to twelve valued group of the skull indices. This is true of the Capito-bicondylar Ratio, but the Ellipticity of the Head and the Condylar Index (1·5 to 1·9 and 3·5 to 4·4 respectively) remain low and appear by whatever standard we judge to be less variable than the indices of the same class for the skull. We should conclude therefore that the perfection of the femoral head as a Hooke joint (see our p. 37) and the proportions of the distal epiphysis as a component of the knee joint have been very stringently selected. It is difficult to pronounce dogmatically about the variation of indices, but on the whole we think it most probable that our numbers indicate a more stringent selection of the hip joint and the knee joint femoral characters than any reduction of variability found for cranial characters so far[1].

If we turn from indices to the question of angles we may compare the variations in the angles of the fundamental triangle of the femur with the variations in the

than less variable. As we have already stated, however, the coefficient of variation of an index while a convenient statement of percentage variation, has not a simple physiological character. If all lengths had the same coefficients of variation v_l, then the coefficient of variation of an index v_i would be $\sqrt{2}\, v_l \sqrt{1-r}$, where r is the correlation of the components of the ratio. Accordingly that index would be less variable when the correlation of its components was greater. This difficulty applies, however, in much the same manner to the standard deviation of an index which also lessens with the increasing correlation of its components. The small value of the Oblique Maximum and Oblique Maximum Trochanteric Indices' coefficients of variation (*i.e.* of order 0·4, see Table IV) is undoubtedly due to the high correlation of their components.

[1] It should be remembered that *roughly* selection of indices is associated with increased correlation of component characters, but that selection of an absolute length marks reduced correlation of that length with other length characters.

angles of the fundamental triangle of the skull (see *Biometrika*, Vol. I, p. 418). We have for males taking the *right* bone:

TABLE XII. *Variation in Angles of Femoral and Cranial Fundamental Triangles in Males* (London 17th century Skeletons).

Femur				Skull			
Angle	Mean	S.D.	C. of V.	Angle	Mean	S.D.	C. of V.
Collar Angle ...	130°·4	6°·68	5·12	Alveolar Angle ...	73°·4	3°·41	4·65
Capital Angle ...	42°·1	5°·63	13·38	Nasional Angle ...	65°·2	3°·52	5·38
Midtrochlear Angle	7°·9	1°·25	15·97	Basional Angle ...	41°·4	2°·50	6·03

The difficulty of variation in angle measurements will at once be grasped from this table. Judged merely from the standard deviations the midtrochlear angle of the femoral fundamental triangle and the angle at the basion in the cranial fundamental triangle have the least variation in the two cases, but judged by the coefficients of variation—since they are the smallest angles they have the highest variations. Are we to assert that the alveolar is more or less variable than the basional angle? or, the collar angle more or less variable than the midtrochlear angle? Judged by either test we think we must conclude that the fundamental triangle of the skull is less variable in its angles than the fundamental triangle of the femur, although it is possible that the collar angle is less variable than nasional or basional angles.

We may, perhaps, compare the obliquity and torsional angles of the femur with the angles which the sides of the cranial triangle make with the Frankfurt Horizonal Plane. We do so again for the male *right* bone:

TABLE XIII. *Variation in Obliquity and Torsion of Femur compared with Inclinations of Sides of Cranial Triangle to Frankfurt Plane* (London 17th century Skeletons).

Femur				Skull			
Angle	Mean	S.D.	C. of V.	Angle	Mean	S.D.	C. of V.
Obliquity ...	8°·7	2°·02	23·23	Profile Angle	86°·1	3°·92	4·55
Torsion of Shaft	21°·7	12°·07	55·45	Angle of Skull Base to horizontal ...	28°·7	2°·53	8·81
Torsional Angle	11°·6	8°·08	75·69	Angle of Profile Length to horizontal	12°·9	3°·34	25·85
Retorsion ...	9°·7	10°·77	110·67	— — —	—	—	—

Now these data again form a striking instance of the difficulty of judging the variation of angles. Judged by the standard deviation the obliquity only is less variable than any of the cranial angles. Judged by the coefficient of variation two cranial angles are less variable than the obliquity. But it is a mere matter of arbitrary definition that we measure the obliquity from the vertical and not from the condylar axis, or the cranial angles from the horizontal plane and not from its normal the vertical. For example in the latter case the coefficients of variation would have

been respectively 100·26, 4·13 and 4·33 instead of 4·55, 8·81 and 25·85, showing a wholly different relative position. Trusting on our part to the standard deviations we assert that the torsional angles of the femur are much more variable than these cranial angles, but the obliquity somewhat less. Thus the obliquity might be assumed to be more intensely, the torsional angles far less intensely selected than the angles the base, profile length and the upper face height of the skull make with the standard horizontal plane.

To sum up, we hold that the skull in its principal lengths and arcs appears to have been more stringently selected than the femur in its absolute dimensions. Also in all angles other than possibly the obliquity there appears to have been greater cranial selection. But in the indices with which the efficiency of the articulations of the femur with pelvis and tibia is associated we find a smallness of variation which does not appear in any characters of the skull yet dealt with.

Note. Since this chapter was printed we have found in our manuscript collections of data the following reductions of Manouvrier and Antony's measurements on 127 femora of both sides and sexes from a neolithic sepulchre at Montigny-Esbly (Bibl. 96, p. 552):

	Mean	Standard Deviation
Platymeric Index.....	77·14	6·504
Pilastric Index.....	111·77	7·694

The means are in fair agreement with the much longer neolithic series of Rodriguez: see Table of Shaft Indices in Chapter VII. But the present interest lies in comparison of these standard deviations with our results tabled on p. 174. The neolithic femora are substantially less variable than recent bones. Now post-mortem selection is chiefly by size, and Table II, p. 194, shows that neither platymeric nor pilastric index is highly correlated with size. Further, our authors measured every available fragment. We conclude therefore that we have here still further good evidence of the truth of the statement of Pearson and Lee that uncivilised races exhibit less variability than civilised races (see our pp. 170 and 174 above).

CHAPTER VI

THE CORRELATION OF CHARACTERS IN THE ENGLISH FEMUR, ITS COMPARISON WITH THAT OF OTHER RACES AND OTHER BONES, AND THE INFLUENCE OF SIDE AND SEX

(i) *General Results and Remarks.*

The accompanying table (Table II, pp. 194–5) contains the chief correlations of characters, 344 in number out of a total of about 400, which we have determined. Many of these have already been cited with the aim of throwing light on special points discussed in the preceding pages, but not all the correlations previously given are here reproduced. We have omitted from the present table all those dealing with anomalies of the femur and many cited in the text of this chapter. The bulk of the present list of correlations applies to quantitatively measurable characters and has been obtained from tables of grouped data by the product-moment method[1]. A few[2] in the case of the curvature of the popliteal surface have been determined by the biserial r process. Lastly a certain number to shorten the great labour of forming additional tables have been found by the coefficient of variation method from the indices[3]. Namely, if $I = 100\,N/D$ be an index, then closely:

$$r_{ND} = \frac{V_N^2 + V_D^2 - V_I^2}{2\,V_N V_D}.$$

The deviation of this index method from the product-moment result depends not only on the fact that it is merely a close approximation[4] but more on the practice—decidedly good in itself—of basing the values of the S.D.'s of the characters on all available material and not merely on those cases for which the indices can be determined. Thus V_N may be found from 250 cases of N, V_D from 233 cases of D, and V_I from only 211 cases where both D and N are available for the same bone. Clearly if we had to recalculate V_N and V_D for every case of a special index the labour would be almost as long as preparing a correlation table of N and D and working it out. The great value of the coefficients of variation method of determining the correlation lies in the fact that the coefficients of variation have already

[1] 244 in all.

[2] 12 in number.

[3] 88 in number.

[4] The correlation as found from the coefficient of variation method differs from that of the *same* cases found by the product-moment method by terms in the numerator of r_{ND} depending on the *fourth* powers of $v_D/100$ and $v_N/100$.

been determined for other purposes, and the additional labour of finding the correlations is thus relatively small. As a measure of the degree of exactness of the coefficients of variation method we note the following values for the correlation found by this method and from actually constructed tables of correlation for the two variates.

TABLE I. *Comparison of Product-Moment and Coefficients of Variation Methods of Determining Correlation-Coefficients.*

Character Pair dealt with	♂ Right		♂ Left		♀ Right		♀ Left	
	Coefficients of Variation	Product Moment	Coefficients of Variation	Product Moment	Coefficients of Variation	Product Moment	Coefficients of Variation	Product Moment
Vertical Diam. of Head and Maximum Length	+·603	+·590±·032	+·545	+·532±·034	+·436	+·411±·047	+·396	+·405±·045
Bicondylar Width and Maximum Length ...	+·586	+·596±·035	+·532	+·516±·039	+·333	+·372±·058	+·480	+·495±·048
Vertical Diam. of Head and Bicondylar Width	+·782	+·750±·024	+·748	+·770±·023	+·647	+·584±·048	+·717	+·654±·038
Pilastric Trans. Diam. and Popliteal Width	+·484	+·504±·033	+·487	+·454±·035	+·489	+·506±·037	+·383	+·407±·042
Pilastric Transverse and Pilastric A.P. Diam.	+·326	+·308±·040	+·355	+·262±·040	+·352	+·283±·046	+·333	+·259±·045
Capito-Collar Length and Maximum Length	+·272	+·303±·042	+·163	+·214±·044	+·073	+·081±·053	+·063	+·070±·052
Capito-Collar Length and Length of Shaft	+·009	+·099±·044	+·000	+·064±·044	−·096*	−·165±·051	−·100	−·035±·050
Max. Length Ext. Cond. and Bicondylar Width	+·761	+·760±·023†	+·764	+·754±·024†	+·593	+·606±·044†	+·685	+·555±·045†

* Omitting a single bone with an extreme outlying and most probably abnormal bust-shaft ratio.

† Oblique Length not Maximum Length in the product-moment values.

Of the 32 values of the correlation given in duplicate in this table 20 pairs have an insignificant difference below the probable error of the product-moment values; 7 pairs have a difference less than 1·5 times the probable error, and of the remaining 5 only one has a difference which exceeds in a marked manner double the probable error; but this occurs in the series of values where we have compared the correlation (♀ L.) of bicondylar width and the *oblique* length of external condyle found by product-moments with the correlation of bicondylar width and the *maximum* length of external condyle. Thus we have a system of differences in correlation values quite compatible with random sampling deviations. *But* it must be remembered that while this statement gives a measure of the differences which are likely to occur, it does not account for them, because the series dealt with by the two methods are not independent random samples; they are largely the same sample. Thus consider the correlation of maximum length of external condyle and bicondylar width in female left bones; the correlation table (see our p. 159) is formed for 107 bones; the coefficients of variation for the bicondylar width, for the maximum length external condyle and for the condylar index are based on 114, 143 and 100 bones respectively. The differences are therefore not inconsiderable, and in

TABLE II. *Classified Coefficients of Correlation: London Femora.*

Index No.	Class	Character Pair	♂ Right		♂ Left		♀ Right		♀ Left	
BB	Whole Bone with Whole Bone	*Oblique with Maximum Length	203	+·996 ± ·0004	214	+·996 ± ·0001	159	+·995 ± ·0005	167	+·996 ± ·0004
		*Oblique Trochanteric with Direct Trochanteric Length	172	+·996 ± ·0004	195	+·997 ± ·0003	135	+·994 ± ·0007	147	+·996 ± ·0004
		Maximum Length with Obliquity of Femur	212	−·141 ± ·045	221	−·043 ± ·045	162	−·080 ± ·053	172	−·014 ± ·051
		Maximum Length with Torsion of Femur	199	−·062 ± ·048	207	−·032 ± ·047	151	+·130 ± ·054	161	+·071 ± ·053
		Obliquity and Robusticity of Femur	200	+·051 ± ·048	212	+·148 ± ·045	154	+·080 ± ·054	160	+·003 ± ·053
		Obliquity and Torsion of Femur	197	+·135 ± ·047	210	−·018 ± ·047	151	−·076 ± ·055	162	+·059 ± ·053
BP	Whole Bone with Proximal Epiphysis	Maximum Length and Vertical Diameter of Head	192	+·590 ± 032	198	+·532 ± ·034	143	+·411 ± ·047	156	+·405 ± ·045
		Maximum Length and Capito-Collar Length	213	+·303 ± ·042	214	+·214 ± ·044	157	+·081 ± ·053	169	+·070 ± ·052
		*Oblique Length and Capito-Collar Length	199	+·298 ± ·044	206	+·225 ± ·045	147	+·030 ± ·056	158	+·086 ± ·053
		Maximum Length and Collar Angle	213	+·282 ± ·043	214	+·249 ± ·043	157	+·185 ± ·052	169	+·237 ± ·049
		Capito-Collar Length and Robusticity of Femur	198	+·165 ± ·047	204	+·174 ± ·046	146	+·204 ± ·053	156	+·161 ± ·053
		Capito-Collar Length and Torsion of Femur	197	−·245 ± ·045	201	−·155 ± ·046	141	−·144 ± ·056	152	−·351 ± ·048
		Obliquity and Collar Angle	209	−·297 ± ·043	217	−·191 ± ·044	150	−·154 ± ·054	163	−·234 ± ·050
		Robusticity of Femur and Collar Angle	198	−·292 ± ·044	204	−·275 ± ·044	146	−·379 ± ·048	156	−·406 ± ·045
BS	Whole Bone with Shaft	Maximum Length and Platymeric Index	216	+·013 ± ·046	223	−·027 ± ·045	165	+·044 ± ·052	176	+·198 ± ·049
		Maximum Length and Pilastric Index	217	+·102 ± ·045	224	+·204 ± ·043	170	+·121 ± ·051	178	+·282 ± ·047
		Maximum Length and Index of Bowing	442	−·041 ± ·032 (R. + L.)			340	−·019 ± ·037 (R. + L.)		
		Obliquity and Index of Bowing	219	+·004 ± ·046	230	−·056 ± ·044	158	+·179 ± ·052	171	−·107 ± ·051
		Torsion of Femur and Length of Shaft	197	−·031 ± ·048	201	−·037 ± ·048	141	+·141 ± ·056	152	+·020 ± ·055
		Torsion of Femur and Index of Bowing	202	−·023 ± ·047	210	−·106 ± ·046	143	−·052 ± ·056	158	−·037 ± ·054
		Torsion of Femur and Platymeric Index	199	−·122 ± ·047	209	−·051 ± ·047	146	−·078 ± ·055	157	+·066 ± ·054
		Torsion of Femur and Pilastric Index	199	−·109 ± ·047	209	−·082 ± ·046	150	+·029 ± ·055	160	+·081 ± ·053
		Torsion of Femur and Popliteal Index	189	+·013 ± ·049	204	−·073 ± ·047	148	−·106 ± ·055	155	−·069 ± ·054
		Robusticity of Femur and Index of Bowing	201	+·368 ± ·041	211	+·159 ± ·045	153	+·262 ± ·051	161	+·176 ± ·052
		Robusticity of Femur and Index of Gracility (Lower)	406	+·245 ± ·031 (R. + L.)			310	+·390 ± ·032 (R. + L.)		
BD	Whole Bone with Distal Epiphysis	Maximum Length and Bicondylar Width	151	+·596 ± ·035	162	+·516 ± ·039	100	+·372 ± ·058	113	+·495 ± ·048
		*Trochanteric Length and Bicondylar Width	135	+·597 ± ·037	148	+·509 ± ·041	93	+·375 ± ·060	104	+·495 ± ·050
		*Trochanteric Length and Maximum Length External Condyle	160	+·611 ± ·033	176	+·619 ± ·031	119	+·449 ± ·049	128	+·377 ± ·051
		Torsion of Femur and Bicondylar Width	147	+·050 ± ·055	159	−·072 ± ·054	98	+·142 ± ·067	110	−·074 ± ·064
PP	Proximal with Proximal Epiphysis	*Vertical Diameter and Horizontal Diameter of Head	176	+·955 ± ·004	190	+·946 ± ·005	130	+·941 ± ·007	149	+·962 ± ·004
		*Vertical Diameter of Head and Capito-Collar Length	197	+·366 ± ·042	204	+·341 ± ·042	146	+·277 ± ·052	160	+·290 ± ·049
		Vertical Diameter of Head and Vertical Diameter of Neck	205	+·758 ± ·020	208	+·772 ± ·019	145	+·612 ± ·035	166	+·656 ± ·030
		*Horizontal Diameter of Head and Horizontal Diameter of Neck	178	+·681 ± ·027	192	+·662 ± ·027	130	+·607 ± ·037	150	+·587 ± ·036
		*Vertical Diameter of Neck and Horizontal Diameter of Neck	224	+·561 ± ·031	235	+·653 ± ·025	164	+·444 ± ·042	186	+·570 ± ·033
		Collar Angle and Capito-Collar Length	227	−·207 ± ·043	229	−·236 ± ·042	167	−·258 ± ·049	182	−·256 ± ·047
PD	Proximal with Distal Epiphysis	Vertical Diameter of Head and Bicondylar Width	146	+·750 ± ·024	146	+·770 ± ·023	87	+·584 ± ·048	104	+·654 ± ·038
		Vertical Diameter of Neck and Bicondylar Width	154	+·683 ± ·029	159	+·692 ± ·028	97	+·297 ± ·062	112	+·388 ± ·054
		Vertical Diameter of Head and Oblique Length External Condyle	183	+·707 ± ·025	181	+·642 ± ·030	124	+·557 ± ·042	133	+·488 ± ·045
		Vertical Diameter of Neck and Oblique Length External Condyle	197	+·527 ± ·035	200	+·540 ± ·034	136	+·367 ± ·050	151	+·275 ± ·051
		*Capito-Collar Length and Bicondylar Width	149	+·376 ± ·047	157	+·335 ± ·048	96	+·150 ± ·067†	105	+·380 ± ·056
PS	Proximal Epiphysis with Shaft	Capito-Collar Length and Length of Shaft	227	+·099 ± ·044	229	+·064 ± ·044	167	−·165 ± ·051	182	−·035 ± ·050
		Collar Angle and Length of Shaft	227	+·078 ± ·044	229	+·063 ± ·044	167	+·079 ± ·052	182	+·064 ± ·050
		Collar Angle and Index of Bowing	459	−·054 ± ·031 (R. + L.)			344	−·081 ± ·036 (R. + L.)		
		Ellipticity of Neck and Index of Bowing	459	−·112 ± ·031 (R. + L.)			341	+·003 ± ·037 (R. + L.)		

* Found by Coefficients of Variation.

† Omitting one extreme and almost certainly abnormal case.

Index No.	Class	Character Pair		♂ Right		♂ Left		♀ Right		♀ Left
PS	Proximal Epiphysis with Shaft (*cont.*)	Capito-Collar Length and Index of Bowing	225	−·136 ± ·044	226	+·066 ± ·045	161	+·009 ± ·053	181	+·023 ± ·050
		Retorsion of Bust with Torsion of Shaft	193	+·729 ± ·023	196	+·663 ± ·027	140	+·608 ± ·036	153	+·579 ± ·036
		Ellipticity of Neck and Platymeric Index	224	−·107 ± ·045	234	+·086 ± ·044	161	+·172 ± ·052	183	+·135 ± ·049
		Vertical Diameter of Head and Pilastric Transverse Diameter	204	+·529 ± ·034	211	+·381 ± ·040	144	+·306 ± ·051	162	+·342 ± ·047
		Vertical Diameter of Head and Length of Shaft	202	+·484 ± ·036	204	+·427 ± 039	140	+·272 ± ·053	161	+·355 ± ·046
SS	Shaft with Shaft	*Length of Shaft and Popliteal Length	222	+·383 ± ·039	223	+·214 ± ·043	166	+·245 ± ·049	178	+·328 ± ·045
		*Popliteal Width and Popliteal Length	225	+·328 ± ·040	237	+·340 ± ·039	178	+·324 ± ·045	183	+·259 ± ·047
		*Diaphysial Chord and Diaphysial Subtense	234	+·229 ± ·042	242	+·322 ± ·039	172	+·346 ± ·045	189	+·337 ± ·043
		*Length of Shaft and Pilastric A. P. Diameter	226	+·263 ± ·042	228	+·399 ± ·038	167	+·246 ± ·049	180	+·459 ± ·040
		*Length of Shaft and Pilastric Transverse Diameter	226	+·193 ± ·043	228	+·164 ± ·043	167	+·121 ± ·051	180	+·108 ± ·050
		Popliteal Width and Pilastric Transverse Diameter	230	+·504 ± ·033	238	+·454 ± ·035	180	+·506 ± ·037	182	+·407 ± ·042
		Pilastric A. P. Diameter and Pilastric Transverse Diameter	236	+·308 ± ·040	249	+·262 ± ·040	183	+·283 ± ·046	192	+·259 ± ·045
		*Platymeric A. P. Diameter and Platymeric Transverse Diameter	236	+·237 ± ·041	247	+·091 ± ·043	179	+·033 ± ·051	198	+·106 ± ·048
		*Platymeric Trans. Diameter and Pilastric Trans. Diameter	236	+·748 ± ·019	247	+·734 ± ·020	179	+·701 ± ·026	193	+·715 ± ·024
		*Popliteal Width and Popliteal Direct A. P. Diameter	225	+·547 ± ·032	236	+·553 ± ·030	181	+·611 ± ·031	184	+·502 ± ·037
		*Popliteal Oblique A. P. and Popliteal Direct A. P. Diameter	228	+·889 ± ·009	235	+·896 ± ·009	179	+·906 ± ·009	184	+·826 ± ·016
		Platymeric Index with Pilastric Index	236	+·551 ± ·031	247	+·455 ± ·034	179	+·388 ± ·043	192	+·405 ± ·041
		Platymeric Index with Popliteal Index	224	+·113 ± ·044	233	+·109 ± ·044	173	+·130 ± ·050	183	+·099 ± ·049
		Pilastric Index with Popliteal Index	225	+·278 ± ·041	235	+·221 ± ·042	181	+·256 ± ·047	185	+·149 ± ·048
		Index of Bowing and Pilastric Index	234	+·257 ± 041	241	+·223 ± ·041	172	+·229 ± ·049	187	+·192 ± ·048
		Index of Bowing and Platymeric Index	234	+·061 ± ·044	241	+·097 ± ·043	170	−·069 ± ·051	187	+·009 ± ·049
		Index of Bowing and Popliteal Index	223	−·097 ± ·045	231	−·004 ± ·044	170	+·044 ± ·052	183	−·102 ± ·049
		Pilastric Index and Index of Gracility (Lower)	229	−·397 ± ·038	238	−·451 ± ·035	179	−·355 ± ·044	182	−·513 ± ·037
		Ditto for constant Pilastric Transverse Diameter	229	−·283 ± ·041	238	−·350 ± ·038	179	−·195 ± ·048	182	−·326 ± ·045
		Torsion of Shaft with Length of Shaft	205	+·062 ± ·047	202	+·086 ± ·047	149	+·161 ± ·054	161	+·124 ± ·052
		Torsion of Shaft with Pilastric A. P. Diameter	208	−·004 ± ·047	210	−·066 ± ·046	159	+·038 ± ·053	164	−·043 ± ·053
		Torsion of Shaft with Pilastric Index	213	+·091 ± ·046	212	+·116 ± ·046	159	+·052 ± ·053	167	+·260 ± ·049
		Torsion of Shaft with Platymeric Index	213	−·059 ± ·046	212	+·065 ± ·046	158	−·020 ± ·054	166	+·136 ± ·051
		Torsion of Shaft with Popliteal Index	198	+·085 ± ·048	206	−·085 ± ·047	156	+·009 ± ·054	160	−·039 ± ·053
		Index of Bowing and Torsion of Shaft	211	−·143 ± ·045	213	−·195 ± ·044	159	−·078 ± ·053	167	−·091 ± ·052
		Convexity of Popliteal Area and Popliteal Index	455	+·436 ± ·035 (R. + L.)			360	+·405 ± ·039 (R. + L.)		
		Convexity of Popliteal Area and Index of Popliteal Skewness	457	+·230 ± ·040 (R. + L.)			359	+·292 ± ·042 (R. + L.)		
		Convexity of Popliteal Area and Index of Gracility (Lower)	459	+·141 ± ·041 (R. + L.)			358	+·115 ± ·044 (R. + L.)		
		Convexity of Popliteal Area and Pyramidal Popliteal Index	453	+·079 ± ·041 (R. + L.)			354	−·074 ± ·045 (R. + L.)		
		Convexity of Popliteal Area and Soffit Index	305	+·245 ± ·048 (R. + L.)			204	+·252 ± ·056 (R. + L.)		
		Convexity of Popliteal Area and Band-radial Index	335	−·039 ± ·048 (R. + L.)			226	−·105 ± ·056 (R. + L.)		
DS	Distal Epiphysis with Shaft	Length of Shaft and Bicondylar Width	147	+·442 ± ·045	159	+·367 ± ·046	95	+·309 ± ·063	105	+·381 ± ·056
		Length of Shaft and Maximum Length External Condyle	194	+·474 ± ·038	189	+·513 ± ·036	129	+·333 ± ·053	139	+·351 ± ·050
		*Popliteal Width and Bicondylar Width	150	+·548 ± ·039	163	+·476 ± ·041	99	+·511 ± ·050	111	+·448 ± ·051
		Index of Bowing and Bicondylar Width	151	−·068 ± ·055	161	−·144 ± ·052	98	−·248 ± ·064	110	+·038 ± ·064
		Pilastric Index and Band-radial Index	160	+·067 ± ·053	176	+·065 ± ·051	112	+·054 ± ·064	114	+·116 ± ·062
		Pilastric Index and Condylar Lengths Index	175	+·086 ± ·051	180	+·022 ± ·050	127	+·083 ± ·059	132	+·131 ± ·058
DD	Distal with Distal Epiphysis	*Bicondylar Width and Maximum Length External Condyle	138	+·761 ± ·024	141	+·764 ± ·024	88	+·593 ± ·047	100	+·685 ± ·036
		Bicondylar Width and Oblique Length External Condyle	151	+·760 ± ·023	154	+·754 ± ·024	94	+·606 ± ·044	107	+·555 ± ·045
		*Max. Length External Condyle and Max. Length Internal Condyle	175	+·765 ± ·021	181	+·791 ± ·019	127	+·689 ± ·022	132	+·672 ± ·023
		Vertical Band-radius and Horizontal Band-radius	160	+·366 ± ·046	177	+·367 ± ·044	112	+·496 ± ·048	115	+·454 ± ·050
		Oblique Length Ext. Condyle and Max. Length Ext. Condyle	188	+·985 ± ·001	190	+·985 ± ·001	131	+·934 ± ·007	136	+·929 ± ·008

* Found by Coefficients of Variation.

such a short series will explain the final divergence[1]. As a means of exhibiting the influence of various sources of divergence we took the series for the pilastric transverse and antero-posterior diameters, and calculated our coefficients of variation on the actual numbers used in the correlation tables and on the same individuals. We found:

	♂ R.	♂ L.	♀ R.	♀ L.
Number:	236	249	183	192
Correlation Table.....	$+ \cdot 308 \pm \cdot 040$	$+ \cdot 262 \pm \cdot 040$	$+ \cdot 283 \pm \cdot 046$	$+ \cdot 259 \pm \cdot 045$
Coefficients of Variation	$+ \cdot 301$	$+ \cdot 306$	$+ \cdot 323$	$+ \cdot 256$

The differences of the two methods are now much reduced, and we may fairly state that worked on the same individuals the differences in the values of the correlation coefficient due to (i) neglected second-order terms which in the present cases do not contribute more than about a unit in the last place of decimals, and (ii) all the individuals in one cell of the correlation table not falling into one and the same cell of the index frequency, the most serious source of error, will not exceed sensibly the probable error. When the various series do not cover the same data the differences will not be greater than those of random sampling[2]. In our Table II of Correlations all values found by the coefficients of variation method are marked by an asterisk. Where the result was reached by alternative methods the product-moment value only was recorded.

(ii) *Racial Comparisons.*

The small material here available is chiefly due to Warren. A 'per mille' correlation table without any reduction has been formed for platymeric and pilastric indices

[1] The reader may ask why if 107 bones were available for the correlation table only 100 were available for the index. The answer is to be found in the attitude adopted in sections of the work undertaken at widely separated periods with regard to certain individuals always on the borderland of acceptance or rejection on account of their classification as young adults, as of very doubtful sex or as having measurements (owing to damaged or pathological condition) of doubtful validity. In every series there may be, perhaps, 20 such bones, and the tabulator has to form a balance between decreasing his numbers and so increasing his probable error, and increasing his numbers at the risk of increasing possible sources of heterogeneity. It is not reasonable to cast aside a bone as doubtful for all measurements; it may be only one or two measurements which have been recorded as doubtful. Thus in each retabling of the measurement cards a possible source of personal equation influence arises. This influence may even be modified by impressions formed in the interval of the nomic or the anomalous position of the individual bone in other series or tables constructed in the interval. Even where a series is sufficiently large—which is certainly not the fact in our present case—and rejection of all doubtful individuals is *a priori* feasible, this rejection may be a real danger, if it be based on personal equation only and take place before recorded measurement.

[2] In a paper to be published shortly in *Biometrika*, Pearson shows that the probable error of the coefficients of variation correlation as deduced from the formula on p. 192 is to the first approximation the same as for the product-moment coefficient. The probable errors attached in our Table II to coefficients found by the coefficients of variation method are based on the sizes of the populations from which the coefficients of variation of the indices have been determined.

by Schwerz (see our Chapter VII) and a few abridged tables for torsion with other characters by Antony and Rivet, but in no cases have the coefficients been found. Parsons himself provides nothing, but we can deduce one or two correlations from the coefficients of variation for his material which we have determined. Speaking generally the material hitherto published has been much too slender to justify correlations being calculated from it. Warren's paper (Bibl. 77) forms the only exception although he has far from exhausted the correlational possibilities of his data; indeed his purpose was a general study of the relations of the long bones rather than a minute study of one of them. He gives three cases of correlation against which we put comparative material.

(*a*) *Capito-collar Length with Oblique Length.*

We have already stated that Warren measures his capito-collar length by ocular appreciation of the coaxial point[1] and that we first used and then discarded this method in favour of a mechanical determination of the coaxial point. Parsons measures what he terms the "length of neck" but we have already noted (see our p. 22) the obscurity of this term as a name for "neck + head," and further the difficulties involved in his method of determining it. Still for throwing light on the important relationship of capito-collar length, we have calculated the four series of Parsons' capito-collar length and oblique length correlations. We also give the results obtained from both our discarded (1st) and final (2nd) measurement of the capito-collar length.

Race	♂				♀			
	No.	R.	No.	L.	No.	R.	No.	L.
Naqada	43	·694 ± ·053	—	—	61	·677 ± ·047	—	—
Rothwell*	76	·508 ± ·057	96	·407 ± ·057	54	·454 ± ·073	47	·469 ± ·077
London (1st method)	199	·578 ± ·032	206	·467 ± ·037	150	·319 ± ·049	159	·319 ± ·047
London (2nd method)	199	·298 ± ·044	206	·225 ± ·045	147	·030 ± ·056	158	·086 ± ·053

* Bibl. 111, pp. 244—251. We have omitted No. 63 of Parsons' left male femora, for it probably belonged to a sub-giant, its length, 543 mm., being greater than those of the femora of the Krainer and Wichsmacher giants' skeletons in the Vienna Museum.

Now these results are of considerable interest for they indicate how great may be the correlation differences associated with different methods of determining a character. Using Warren's method of appreciative fixing of the coaxial point, we obtained somewhat smaller values than he has done for the male bones, and markedly smaller for the female bones. His results show considerable correlation for both sexes, and slight but not really significant sexual difference. Parsons' data give results lower than Warren's and about the same order as ours for male bones, but show no sexual difference; this tends to confirm our doubts as to the validity of his sexing by size of head. Finally, our results obtained by a purely mechanical fixing of the coaxial point show a sensible but small correlation in the male bones, while the female correlation

[1] Warren does not publish his correlation table, but that his values are correct appears clear by applying the coefficients of variation method, which gives values over ·6.

has sunk to insignificance. Either of our methods leads to the same conclusions namely that the correlation of these characters is higher in the more primitive race and that the sexes are more nearly equal in correlation in the more primitive race. The former conclusion is supported by the Rothwell data, but not the second. At a first examination it might be suggested that the high correlation arises from taking the shorter measurement to the spiral line (as Parsons) and not to the coaxial point. But Warren and we also get correlations as high as Parsons when we measure to the coaxial point, *provided that point be determined by ocular appreciation.* It seems to us that the tendency with a big and massive bone is to place the coaxial point further on to the body of the bone, the judgment by appreciation being possibly influenced by the balance of a massive minor trochanter. The effect of this would be to increase the correlation between capito-collar length and maximum length of femur. It would also increase the collar angle and accordingly we do find our first method gives higher values for the correlation of size and collar angle than our second: *i.e.*

Correlations of Maximum Length and Collar Angle.

1st method: ♂ R. $+ \cdot 333 \pm \cdot 042$, ♂ L. $+ \cdot 258 \pm \cdot 043$, ♀ R. $+ \cdot 298 \pm \cdot 048$, ♀ L. $+ \cdot 243 \pm \cdot 048$.
2nd method: ♂ R. $+ \cdot 282 \pm \cdot 043$, ♂ L. $+ \cdot 249 \pm \cdot 043$, ♀ R. $+ \cdot 185 \pm \cdot 052$, ♀ L. $+ \cdot 237 + \cdot 049$.

Here, as in the measurements of capito-collar length and maximum length, there appears to be more correlation in the male. Without being dogmatic where results are to some extent contradictory, we are inclined to think that there is not a very high correlation between size of bust and size of the whole bone[1], and possibly owing to selection in the case of the female[2] less correlation in the female than the male.

(*b*) *Collar Angle with Primary Bust Ratio.*

This is Warren's correlation of Angle of Neck with (Neck + Head)/Femur (*i.e.* maximum length)[3]:

	No.	Correlation		No.	Correlation
♂	45	$- \cdot 345 \pm \cdot 089$	♀	88	$- \cdot 273 \pm \cdot 067$

We have not directly found this correlation of collar angle with primary bust ratio. But if α be the angle, β the bust ratio, c the capito-collar length, m the maximum length, then it is easy to deduce that:

$$r_{\alpha\beta} = \frac{V_c r_{ac} - V_m r_{am}}{\sqrt{V_c^2 + V_m^2 - 2 V_c V_m r_{mc}}},$$

and the values of V_c, V_m are given in Table III of p. 164 and those of r_{ac}, r_{am}, r_{mc} in Table II of pp. 194–5.

Substituting we find for the London femora:

		No.	Correlation		No.	Correlation
♂	R.	218	$- \cdot 367 \pm \cdot 040$	♀	R. 171	$- \cdot 326 \pm \cdot 046$
	L.	225	$- \cdot 362 \pm \cdot 039$		L. 181	$- \cdot 350 \pm \cdot 044$

[1] This is confirmed by the low correlations found between capito-collar length and length of shaft.

[2] If a definite pelvic width be of importance in the female, a *negative* correlation between a short femur and a long neck and head might even be evolved.

[3] Bibl. No. 77, p. 152.

It will be clear from the probable errors that in the relation of the collar angle to the relative length of the bust there is no racial difference between Naqada and English. In both cases a relatively short neck and head signifies a larger collar angle, and this compensatory process—which removes the short shaft further from the pelvis —appears to be somewhat more intense in man than woman. An examination of the absolute correlations of capito-collar length and collar angle shows that the sign is consistently negative or an absolutely short bust, as well as a relatively short one, is associated with a large collar angle. Humphry has stated[1] that the collar angle is smaller in short bones than in long bones, and in women than in men. Our Table I, p. 115, shows that the second part of the statement is true and the values given for the correlations of collar angle and maximum length in Table II, p. 194, being all positive it is clear that the first part of Sir George's statement is again true, at least for English material. Dr Warren's statement is also true for it applies *to the size of bust relative to the size of femur*, and we think that it is not in any way opposed to the other aspect of the matter.

If instead of proceeding by the primary bust ratio we had used partial correlation, we should have found:

Partial Correlations of Collar Angle and Bust Length for constant Maximum Length of Femur:

♂ R. $-\cdot319$; ♂ L. $-\cdot305$; ♀ R. $-\cdot279$; ♀ L. $-\cdot282$.

The partial correlations of collar angle and maximum length of femur for constant capito-collar length are all positive and somewhat smaller than these. We conclude that the collar angle decreases as the bust increases and this is true whether we take the relative or absolute length of the capito-collar axis.

(*c*) *Obliquity and Maximum Length.*

Dr Warren gives for the Naqada femora the following results for R. bones:

	No.	Correlation
♂	80	$-\cdot0395 \pm \cdot0753$
♀	113	$+\cdot0192 + \cdot0634$

Thus there is no relationship demonstrable between obliquity and size of femur in the Naqada race. We find for the London material:

		No.	Correlation
♂	R.	212	$-\cdot141 \pm \cdot045$
	L.	221	$-\cdot043 \pm \cdot045$
♀	R.	162	$-\cdot080 \pm \cdot053$
	L.	172	$-\cdot014 \pm \cdot051$

With the exception of ♂ R. none of these values can be considered to approach significance, but the fact that ♂ L. and ♀ R. and L. all support the sign of the correlation in ♂ R. suggest that a slender relation may really exist and that the longer the bone the less in a very small degree is the obliquity, *i.e.* the requisite breadth at the acetabular axis might be reached by either obliquity or length of femur.

Warren's paper presents no further purely femoral correlations for comparison with our data.

[1] Bibl. 45.

A few further comparisons of correlations can be made as follows:

(*d*) *Platymeric Antero-Posterior with Platymeric Transverse Diameter*[1].

Race	No.	♂ R.	No.	♂ L.	No.	♀ R.	No.	♀ L.
Rothwell "Medieval"	80	+·195 ± ·073	105	+·308 ± ·060	57	+·307 ± ·081	50	+·304 ± ·087
17th century Londoners	236	+·237 ± ·041	247	+·091 ± ·043	179	+·033 ± ·051	198	+·106 ± ·048
Modern British	43	(R. + L.) +·432 ± ·084			—	—	—	—

Except for ♂ R. the Rothwell data give values much in excess of ours. Hepburn's "Modern British" give a still higher value of the correlation, but we believe this to be due almost entirely to the heterogeneity of Hepburn's series. The evidence of this heterogeneity may be found in the magnitude of his standard deviations; for example, his diameter of head has a standard deviation of 4·791 mm., more than double that of Parsons' and approaching double our values. Parsons' platymeric section does not agree with ours, and therefore his correlation values are not really comparable. His distribution of frequency of platymeric indices in ♂ R. differs very widely from that of ♂ L. providing a standard deviation of R. 8·201 as compared with L. 6·555. While his 105 left male bones show no index below 68 and only one of that value, his 25 fewer right males show five values below 68, namely one at 67, two at 65, one at 63 and one at 59 even! We must either assume that he has struck a pocket of very platymeric right bones or that his numbers are inadequate to exhibit the true variation and so the correlation. We think there is little knowledge to be gained from comparison of these values, and believe, till further evidence is forthcoming, that when the platymeric diameters are measured by Manouvrier's rule there is only small relationship between them.

(*e*) *Pilastric Antero-Posterior with Pilastric Transverse Diameter.*

Our only comparative value is that deduced from Hepburn's material[1]:

Race	No.	♂ R.	No.	♂ L.	No.	♀ R.	No.	♀ L.
17th century Londoners	236	+·308 ± ·040	249	+·262 ± ·040	183	+·283 ± ·046	192	+·259 ± ·045
Modern British	43	(R. + L.) +·666 ± ·057			—	—	—	—

That Hepburn's value is more than twice ours, we think cannot be due to difference of period, but can only be accounted for by the heterogeneity of his material.

This section of our paper will at any rate have served a useful purpose, if it draws attention to the practical absence at present of all comparative racial data for the correlation of characters in any long bone, and further if it emphasizes the repeatedly disregarded point that had material indeed been measured and reduced it would have been of small service without some standardization of methods of measurement.

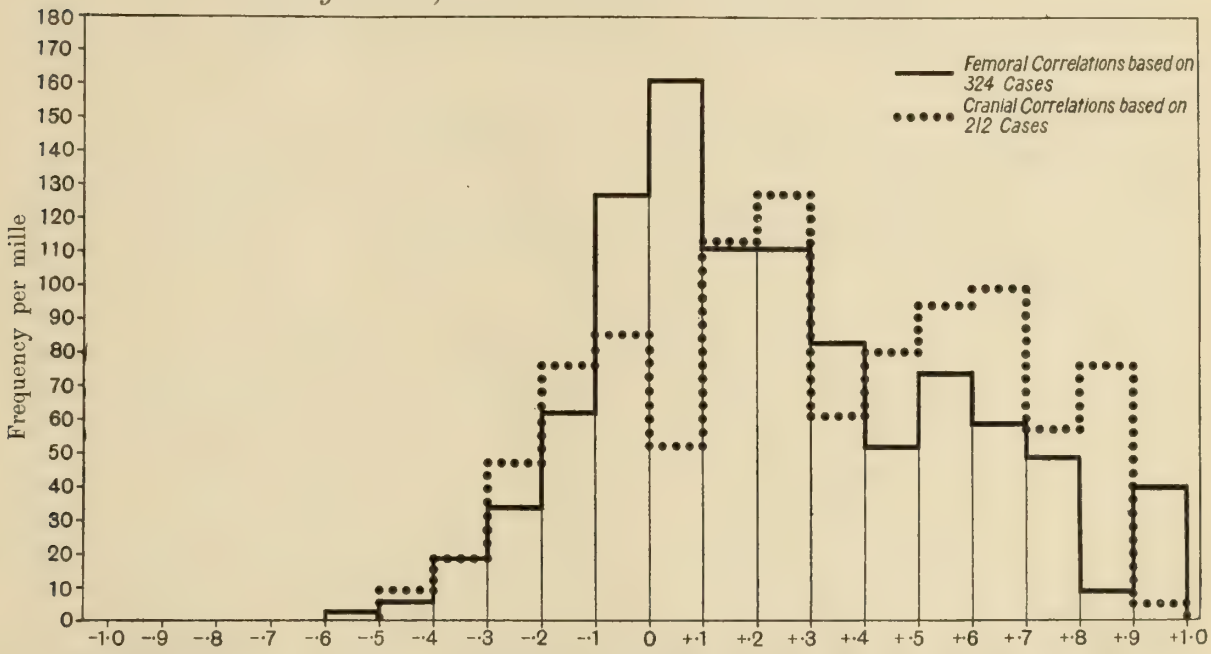
[1] Values found by coefficients of variation method.

(iii) *Comparison of Femoral Correlations with those of other Parts of the Skeleton.*

This section unfortunately must be very brief, if we desire to compare our 344[1] femoral correlations with a similar series for another bone. So far we believe no such long series has been published, and it will only be possible in later parts of this monograph to compare with similar series for the other long bones. We could compare the correlations of our femoral series with those for the bones of the hand, but this is really to compare the correlations of parts of one bone with the correlations of several bones with one another. Much the same remark applies to cranial correlations, although the bones of the cranium are more closely united than those of the hand. We have, however, placed in juxtaposition some 212 cranial correlations determined in the Biometric Laboratory and 324 femoral correlations drawn from the present memoir[2]. They are exhibited in the diagram below.

The mean of the femoral series is $\cdot 232 \pm \cdot 012$ and of the cranial series $\cdot 298 \pm \cdot 016$. The cranial correlations thus appear to be higher to some extent than the femoral and this is evident from the histograms of the diagram.

Histograms of Femoral and Cranial Correlations.



Femoral Correlations	3	6	19	34	62	127	161	111	111	83	52	74	59	49	9	40		
Cranial Correlations	—	9	19	47	76	85	52	113	127	61	80	94	99	57	76	5		

[1] That is the full number of correlation coefficients in Table I. This chapter, however, contains 386 newly calculated coefficients in tables and text and the whole memoir well over 400. It is the calculation of so many correlations which has largely delayed the appearance of this study.

[2] At the time this diagram was prepared only 324 femoral correlations had been determined, 20 more were added later and are included in Table I. These are Vertical Diameter of Head with Pilastric Transverse Diameter, Vertical Diameter of Head with Length of Shaft, Length of Shaft with Bicondylar Width, Length of Shaft with Maximum Length of External Condyle, and Oblique Length of External Condyle with its Maximum Length, each for the two members and both sexes

But it is very doubtful whether we can assert on the basis of these results that cranial correlations are higher than femoral. For in the first place our cranial correlations are drawn from a variety of races, and our femoral from one only. In the next place the highest cranial correlations are those connecting external measurements with capacity, a character having no analogy with any femoral character. Further we have found a very considerable number of femoral correlations from indices and this regardless of whether the components of the indices were or were not likely to provide interesting associations. We have in fact been far more catholic in our determination of femoral than of cranial correlations, and the result is that our series contains a much larger number of correlations which centre about zero, *i.e.* are of the type of small correlations which appear when we sample from uncorrelated material. It may indeed be doubted whether it would be well to insist on higher correlation existing on the average between parts of the skull than between characters of the femur. At the same time the publication of the frequencies of these two series of correlations may be helpful if it warns the reader of the evil of applying Bayes' Theorem to determine the "most likely value" of the correlation in a small sample of crania or femora, or indeed of any anthropometric material. In neither case is there any approach to a uniform distribution of correlation values, and in particular there is a complete absence in both instances of high negative correlations.

(iv) *On the Influence of Side on Correlation.*

In the table on p. 203 are given all cases in which the differences of the right and left member correlations exceed twice the probable error of that difference in either sex. The values for both sexes are given in order to determine how far there is confirmation of results.

Of the 162 coefficients of correlation which can be compared on left and right sides all but 27 differences are probably insignificant. Of these 27, 20 are possibly significant and 7 may be considered probably significant. Of the former 14 are female and 6 male, and of the latter 4 female and 3 male. Thus the mere possibility of right and left differentiation in correlation seems much greater in the female than the male. But of the 9 male and 18 female characters which show possible or probable significance only two pairs are the same. The correlation of length of shaft and pilastric antero-posterior diameter in the female shows *probably* superior correlation in the left member, while in the male there is *possibly* superior correlation in the left. The correlation of the minimum vertical and horizontal diameters of the neck shows *possibly* superior correlation in the left in both male and female. In all the other cases of possible significance of right and left difference the male not only does not support the female or the female the male, but not infrequently the second sex reverses the member which has the superior correlation in the first sex[1]. If we turn to the probably significant correlation differences, we note that of the four

[1] To judge this one must note that the sign in brackets in the $\Delta_{R.-L.} \pm e_{\Delta}$ columns of the table is that of the correlation in the right member. If the sign which follows this is the *same* the right femur has greater *numerical* correlation; if the sign is reversed it has less.

TABLE III. *Differences of Correlation in R. and L. Femora.*

	Character Pair Correlated	♂		♀	
		$\Delta_{R.-L.} \pm e_\Delta$	$\frac{\Delta_{R.-L.}}{e_\Delta}$	$\Delta_{R.-L.} \pm e_\Delta$	$\frac{\Delta_{R.-L.}}{e_\Delta}$
Probably Significant	Popliteal Oblique and Direct Ant. Post. Diam.	(+) − ·007 ± ·013	[0·5]	(+) + ·080 ± ·018	4·4
	Obliquity and Index of Bowing	(−) − ·060 ± ·064	[0·9]	(−) − ·286 ± ·073	3·9
	Length of Shaft and Pilastric Ant. Post. Diam.	(+) − ·136 ± ·057	2·4	(+) − ·213 ± ·063	3·4
	Robusticity of Femur and Index of Bowing ...	(+) + ·209 ± ·061	3·4	(+) + ·086 ± ·073	[1·2]
	Index of Bowing and Bicondylar Width ...	(−) + ·076 ± ·076	[1·0]	(−) − ·286 ± ·091	3·2
	Capito-Collar Length and Index of Bowing ...	(−) − ·202 ± ·063	3·2	(+) − ·014 ± ·073	[0·2]
	Ellipticity of Neck and Platymeric Index ...	(−) − ·193 ± ·063	3·3	(+) + ·037 ± ·071	[0·5]
Possibly Significant	Torsion of Shaft and Platymeric Index ...	(+) − ·025 ± ·065	[0·4]	(+) − ·208 ± ·072	2·9
	Vertical Diam. of Head and Pilastric Trans. Diam.	(+) + ·148 ± ·052	2·8	(+) − ·036 ± ·069	[0·5]
	Pilastric Index and Index of Gracility (Lower)	(−) + ·054 ± ·052	[1·0]	(−) + ·158 ± ·057	2·8
	Capito-Collar Length and Torsion of Femur ...	(−) − ·090 ± ·064	[1·4]	(−) + ·207 ± ·074	2·8
	Vertical and Horizontal Diameters of Head ...	(+) + ·009 ± ·006	[1·5]	(+) − ·021 ± ·008	2·6
	Capito-Collar Length and Bicondylar Width ...	(+) − ·041 ± ·067	[0·6]	(+) − ·230 ± ·087	2·6
	Platymeric Ant. Post. and Trans. Diameters ...	(+) + ·146 ± ·059	2·5	(+) − ·073 ± ·070	[1·0]
	Popliteal Index and Torsion of Shaft	(+) + ·170 ± ·067	2·5	(+) + ·048 ± ·076	[0·6]
	Vert. Diam. of Neck and Horiz. Diam. of Neck	(+) − ·092 ± ·040	2·3	(+) − ·126 ± ·053	2·4
	Maximum Length and Pilastric Index	(+) − ·102 ± ·062	[1·6]	(+) − ·161 ± ·069	2·3
	Torsion of Femur and Bicondylar Width ...	(+) + ·122 ± ·077	[1·6]	(+) + ·216 ± ·093	2·3
	Popliteal Width and Popl. Direct Ant. Post. Diam.	(+) − ·006 ± ·044	[0·1]	(+) + ·109 ± ·048	2·3
	Maximum Length and Platymeric Index ...	(+) + ·040 ± ·064	[0·6]	(+) − ·154 ± ·071	2·2
	Torsion of Shaft and Platymeric Index ...	(−) − ·124 ± ·065	[1·9]	(−) − ·156 ± ·074	2·2
	Capito-Collar Length and Length of Shaft ...	(+) + ·035 ± ·062	[0·6]	(−) − ·130 ± ·062	2·1
	Platymeric and Pilastric Indices	(+) + ·096 ± ·046	2·1	(+) − ·017 ± ·059	[0·3]
	Index of Bowing and Popliteal Index	(−) − ·093 ± ·063	[1·5]	(+) + ·146 ± ·071	2·1
	Pilastric Index and Index of Gracility (Lower) for constant Pilastric Transverse Diameter	(−) + ·067 ± ·056	[1·2]	(−) + ·131 ± ·066	2·0

female significances, one only is associated with a possible male significance; in the other three cases not only are the male differences quite insignificant, but two of them are associated with a reversal of the member showing the higher correlation. The three male probably significant differences are all associated with cases of female insignificant differences, and in two of these cases the very signs of the correlations themselves are opposite in male and female. We conclude accordingly that there are practically no substantial differences in the correlation of right and left members due to rightness and leftness as apart from sex. Such differences, few in number, as appear to be significant, are presumably secondary sexual differences and are not identical for the two sexes. We have come across no case in which the right and left members indicate probably significant differences in correlation for both sexes alike.

Although there are so few significant differences between R. and L. correlations taken individually, it is worth inquiring whether there is any predominance in our long series as a whole. Out of 162 pairs of correlation coefficients there are 116 in which the correlation is positive in both right and left members; the correlations are equal in two pairs, in excess 63 times on the right and 51 times on the left. The average would be 57, or there is a deviation of 6·0 which is

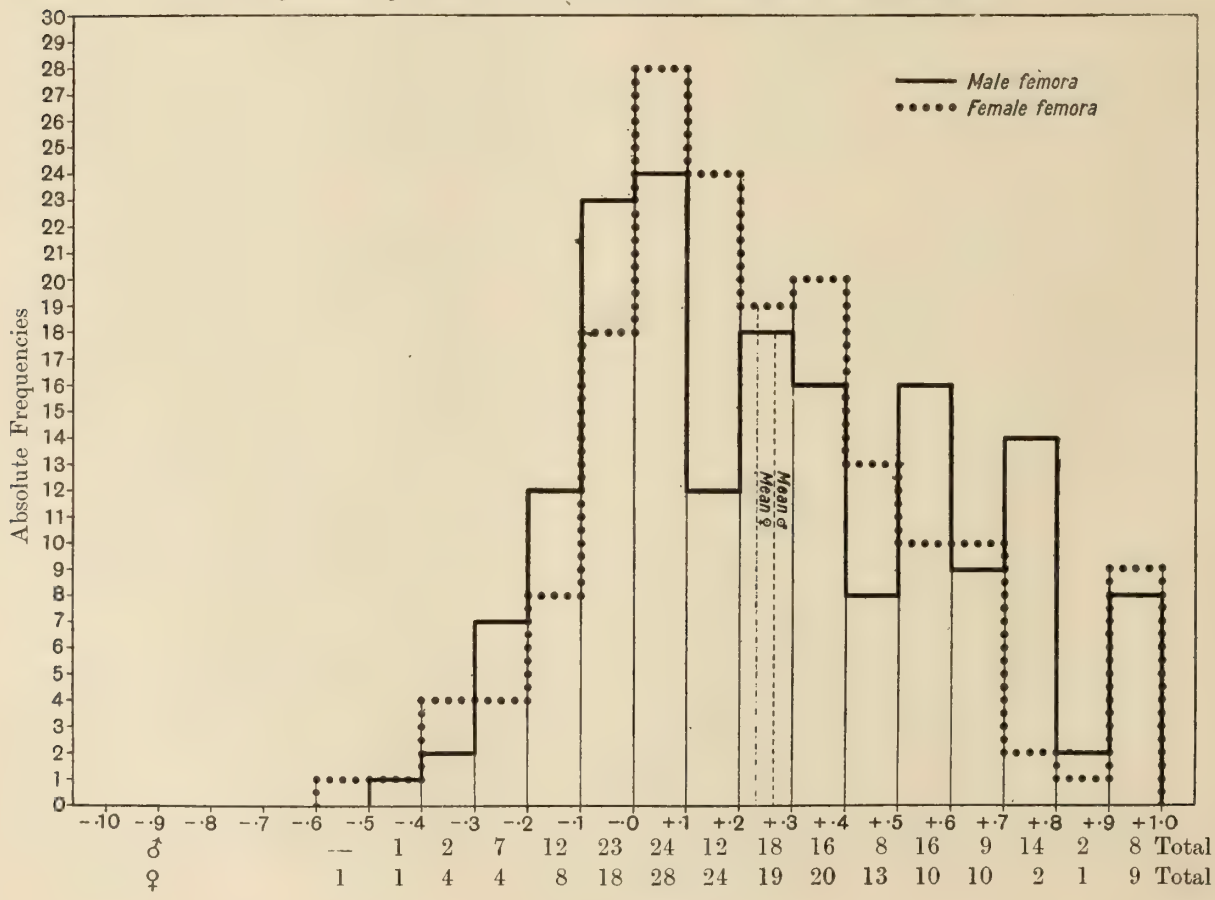
only slightly above the magnitude of the standard-deviation (5·4) on the basis of an even chance of R. or L. happening to be the greater. Of the 27 cases in which both correlations are negative, in 13 the right, in 14 the left has the greater *numerical* value. There are 19 cases in which the correlations are small and of opposite sign, in 9 the numerical value is greater on the right, in 10 on the left. It is clear that there is no general predominance in correlation of either member. This result appears to confirm our previous conclusion of the relatively small extent of side differentiation. Had selective influences produced sensible differentiation in size of right and left bones, it would have been very unlikely that the correlations should not have shown more marked signs of inequality. For such selection modifies correlation.

(v) *On the Influence of Sex on the Femoral Correlations.*

A very little examination of our table on pp. 194—5 will convince the reader of a predominance of the male correlations over the female. At the time when we took statistics of the matter 172 pairs of correlations were available for comparison. An examination of the diagram shows the preponderance of males over females in the substantial correlations above ·5. Actually the means are

$$♂ :— \bar{r} = ·263 \pm ·017, \qquad ♀ :— \bar{r} = ·233 \pm ·016.$$

Histograms of Male and Female Femoral Correlations.



But a more striking analysis is as follows: Of the 121 correlations which are positive in both sexes no less than 86 have a greater value in the male, 34 only are greater in the female and there is one case in which the correlations are equal. In 30 cases the correlations are negative in both sexes, and of these the male is numerically greater in 16, the female in 14; while of those 21 which have unlike signs 10 are numerically greater in the male, 11 in the female. Thus judged, as we think the matter must be, by the correlations positive in both sexes, the male shows a noteworthy excess of correlation. In the negative and opposite sign correlations —which are usually small and due probably to small samples from material really uncorrelated—the sexes are fairly balanced.

It remains to consider in what pairs of characters the sexual difference is most marked, and then if possible to suggest a reason for this great sexual difference. The contrast between Tables III and IV is marked and indicates how much more important sex is than side as a factor of differentiation. For sex we have *eight* differences which are four or more times their probable errors in comparison with *one* only for side. For sex we have 21 differences between three and four times their probable errors as compared with six only in the case of side. And lastly for sex we have 32 differences between two and three times their probable errors as compared with only 20 in the case of side. Or looked at from another standpoint 135 out of 162 pairs of correlations have insignificant differences in the case of side, but only 111 out of 172 pairs in the case of sex. Another easily appreciated point in the table is: that of the 61 probably or possibly significant differences in correlation 53 show greater correlation in the male bones. Of the 29 probably significant sex differences in correlation only *two* show preponderance of correlation in the female, *i.e.* Robusticity of the Femur with Index of Gracility (Lower) for the right and left bones combined, with a difference 3·2 times its probable error, and capito-collar length with torsion of femur on the left side with a difference three times its probable error. This latter difference is insignificant and reversed on the right side. Of the 32 *possibly* significant sex differences only six show predominance of female correlation. They are:

(*a*) Obliquity and Index of Bowing on right side with ratio 2·5. This is insignificant (0·8) on left side, where the correlation is indeed of opposite sign.

(*b*) Index of Bowing and Bicondylar Width on right side (2·1). There is male preponderance with a higher ratio (2·5) on the left side.

(*c*) Vertical and Horizontal Band-Radii (2·0) on the right side. The difference has the same sign, but is insignificant (1·3) on left.

(*d*) Torsion of Shaft and Pilastric Index on the left (2·1). This is insignificant (0·6) and reversed on right.

(*e*) Robusticity of Femur and Collar Angle on the left (2·1). This is of the same sign, but insignificant (1·3) on the right.

(*f*) Oblique and Maximum Trochanteric Lengths (2·0) on the left. This is more significant (2·5), but reversed on the right.

Table IV. *Differences of Male and Female Correlations.*

	Right Side				Left Side				
	Character Pair	$\Delta_{\sigma - \varphi} \pm e_\Delta$	$\frac{\Delta_{\sigma - \varphi}}{e_\Delta}$	L. Order	Character Pair	$\Delta_{\sigma - \varphi} \pm e_\Delta$	$\frac{\Delta_{\sigma - \varphi}}{e_\Delta}$	R. Order	
Most Probably Significant	1. Obl. and Max. Lengths Ext. Condyle ...	(+) + ·051 ± ·007	7·3	1	1. Obl. and Max. Lengths Ext. Condyle ...	(+) + ·056 ± ·008	7·0	1	Most Probably Significant
	2. Vert. Diam. of Neck and Bicondylar Width ...	(+) + ·386 ± ·068	5·7	2	2. Vert. Diam. of Neck and Bicondylar Width ...	(+) + ·304 ± ·060	5·1	2	
	3. Ellipticity of Neck and Platymeric Index ...	(−) − ·279 ± ·069	4·0	52	3. Vert. Diam. of Neck and Obl. Length Ext. Cond.	(+) + ·265 ± ·061	4·3	26	
Probably Significant	4. Capito-Collar and Shaft Lengths	(+) + ·264 ± ·067	3·9	30	4. Trochanteric Length and Max. Length Ext. Cond.	(+) + ·242 ± ·060	4·0	24	
	5. Max. Length and Vert. Diam. of Head ...	(+) + ·179 ± ·047	3·8	21	5. Max. Lengths of Ext. and Int. Condyles ...	(+) + ·119 ± ·030	4·0	30	
	6. Obl. Length and Capito-Collar Length ...	(+) + ·268 ± ·071	3·8	22	6. Bicondylar Width and Obl. Length Ext. Condyle	(+) + ·199 ± ·051	3·9	19	Probably Significant
	7. Vert. Diameters of Head and Neck	(+) + ·146 ± ·040	3·7	9	7. Popliteal Obl. and Direct A. P. Diameters ...	(+) + ·070 ± ·018	3·9	56	
	8. Vert. Diam. of Head and Pilastric Trans. Diam.	(+) + ·223 ± ·061	3·7	56	8. Max. Length and Platymeric Index	(−) − ·225 ± ·067	3·4	74	
	9. Vert. Diam. of Head and Length of Shaft ...	(+) + ·212 ± ·064	3·3	38	9. Vert. Diameters of Head and Neck	(+) + ·116 ± ·036	3·2	7	
	10. Max. Length and Capito-Collar Length ...	(+) + ·222 ± ·068	3·3	17	10. Capito-Collar Length and Torsion of Femur ...	(−) + ·196 ± ·066	3·0	50	
	11. Max. Length and Bicondylar Width	(+) + ·224 ± ·068	3·3	65	11. Vert. Diam. of Head and Obl. Length Ext. Cond.	(+) + ·154 ± ·054	2·9	16	Possibly Significant
	12. Robusticity of Femur and Ind. of Gracility (Lower)	(+) − ·145 ± ·045	3·2	(R. + L.)	12. Bicondylar Width and Vert. Diam. of Head	(+) + ·116 ± ·044	2·6	15	
	13. Trochanteric Length and Bicondylar Width ...	(+) + ·222 ± ·070	3·2	72	13. Length of Shaft and Max. Length Ext. Condyle	(+) + ·162 ± ·062	2·6	25	
	14. Bicondylar Width and Max. Length Ext. Cond.	(+) + ·168 ± ·053	3·2	26	14. Torsion of Femur and Pilastric Index ...	(−) − ·163 ± ·070	2·3	39	
	15. Bicondylar Width and Vert. Diam. of Head	(+) + ·166 ± ·054	3·1	12	15. Index of Bowing and Bicondylar Width ...	(−) − ·182 ± ·082	2·2	37	
	16. Vert. Diam. of Head and Obl. Length Ext. Cond.	(+) + ·150 ± ·049	3·1	11	16. Obliquity and Robusticity of Femur	(+) + ·145 ± ·070	2·1	76	
	17. Platymeric A. P. and Trans. Diameters ...	(+) + ·204 ± ·065	3·1	73	17. Max. Length and Capito-Collar Length ...	(+) + ·144 ± ·068	2·1	10	
	18. Platymeric and Pilastric Indices	(+) + ·163 ± ·053	3·1	78	18. Torsion of Shaft and Pilastric Index	(+) − ·144 ± ·067	2·1	70	
	19. Bicondylar Width and Obl. Length Ext. Condyle	(+) + ·154 ± ·050	3·1	6	19. Robusticity of Femur and Collar Angle ...	(−) + ·131 ± ·063	2·1	54	
Possibly Significant	20. Obliquity and Torsion of Femur	(+) + ·211 ± ·072	2·9	40	20. Oblique and Direct Trochanteric Lengths ...	(+) − ·001 ± ·0005	2·0	28	
	21. Capito-Collar Length and Bicondylar Width	(+) + ·226 ± ·082	2·8	54	21. Max. Length and Vert. Diam. of Head ...	(+) + ·127 ± ·065	2·0	5	
	22. Retorsion of Bust and Torsion of Shaft ...	(+) + ·121 ± ·043	2·8	24	22. Obl. Length and Capito-Collar Length ...	(+) + ·139 ± ·070	2·0	6	
	23. Maximum Length and Torsion of Femur ...	(−) − ·192 ± ·072	2·7	29	23. Vert. and Horiz. Diameters of Neck	(+) + ·083 ± ·041	2·0	33	
	24. Trochanteric Length and Max. Length Ext. Cond.	(+) + ·162 ± ·059	2·7	4	24. Retorsion of Bust and Torsion of Shaft ...	(+) + ·084 ± ·045	1·9	22	Insignificant
	25. Length of Shaft and Max. Length Ext. Condyle	(+) + ·141 ± ·052	2·7	13	25. Length of Shaft and Popliteal Length ...	(+) − ·114 ± ·062	1·8	34	
	26. Vert. Diam. of Neck and Obl. Length Ext. Cond.	(+) + ·160 ± ·061	2·6	3	26. Bicondylar Width and Max. Length Ext. Cond.	(+) + ·079 ± ·043	1·8	14	
	27. Convexity Popl. Area and Pyram. Popl. Index	(+) + ·153 ± ·061	2·6	(R. + L.)	27. Horiz. Diameters of Head and Neck	(+) + ·075 ± ·045	1·7	47	
	28. Oblique and Direct Trochanteric Lengths ...	(+) + ·002 ± ·0008	2·5	20	28. Torsion of Femur and Platymeric Index ...	(−) − ·117 ± 072	1·6	67	
	29. Obliquity and Index of Bowing	(−) + ·175 ± ·069	2·5	48	29. Max. Length and Torsion of Femur	(−) − ·103 ± ·071	1·5	23	
	30. Max. Lengths Ext. and Int. Condyles ...	(+) + ·076 ± ·030	2·5	5	30. Capito-Collar and Shaft Lengths	(+) + ·099 ± ·067	1·5	4	
	31. Ellipticity of Neck and Index of Bowing ...	(−) − ·115 ± ·048	2·4	(R. + L.)	31. Index of Bowing and Popliteal Index ...	(−) + ·098 ± ·066	1·5	65	
	32. Torsion of Femur and Length of Shaft ...	(−) − ·172 ± ·074	2·3	48	32. Index of Bowing and Torsion of Shaft ...	(−) − ·104 ± ·068	1·5	63	
	33. Vert. and Horiz. Diameters of Neck	(+) + ·117 ± ·052	2·3	23	33. Pilastric and Condylar Lengths Indices ...	(+) − ·109 ± ·077	1·4	91	
	34. Length of Shaft and Popliteal Length ...	(+) + ·138 ± ·063	2·2	25	34. Index of Bowing and Platymeric Index ...	(+) + ·088 ± ·065	1·4	41	
	35. Obliquity and Collar Angle	(−) − ·143 ± ·069	2·1	53	35. Popliteal Width and Popliteal Length ...	(+) + ·081 ± ·061	1·3	87	
	36. Capito-Collar Length and Index of Bowing ...	(−) − ·145 ± ·069	2·1	55	36. Vert. and Horiz. Band-Radii	(+) − ·087 ± ·067	1·3	38	
	37. Index of Bowing and Bicondylar Width ...	(−) + ·180 ± ·084	2·1	15	37. Max. Length and Pilastric Index	(+) − ·078 ± ·064	1·2	83	
	38. Vert. and Horiz. Band-Radii	(+) − ·130 ± ·066	2·0	36	38. Vert. Diam. of Head and Length of Shaft ...	(+) + ·072 ± ·060	1·2	9	
Insignificant	39. Torsion of Femur and Pilastric Index ...	(−) − ·138 ± ·072	1·9	14	39. Pilastric Index and Index of Gracility (Lower)	(−) + ·062 ± ·051	1·2	66	
	40. Diaphysial Chord and Subtense	(+) − ·117 ± ·062	1·9	67	40. Obliquity and Torsion of Femur	(−) − ·077 ± ·071	1·1	20	
	41. Index of Bowing and Platymeric Index ...	(+) + ·130 ± ·067	1·9	34	41. Popl. Width and Popl. Direct A. P. Diameter	(+) + ·051 ± ·048	1·1	53	
	42. Vert. and Horiz. Diameters of Head	(+) + ·014 ± ·008	1·8	45	42. Pilastric and Popliteal Indices	(+) + ·072 ± ·064	1·1	80	
	43. Oblique and Maximum Lengths	(+) + ·001 ± ·0006	1·7	79	43. Length of Shaft and Pilastric A. P. Diameter	(+) − ·060 ± ·055	1·1	84	
	44. Length of Shaft and Bicondylar Width ...	(+) + ·133 ± ·077	1·7	75	44. Torsion of Femur and Index of Bowing ...	(−) − ·069 ± ·071	1·0	78	
	45. Torsion of Femur and Popliteal Index ...	(+) + ·119 ± ·074	1·6	76	45. Vert. and Horiz. Diameters of Head	(+) − ·006 ± ·006	1·0	42	
	46. Robusticity of Femur and Index of Bowing ...	(+) + ·106 ± ·065	1·6	71	46. Torsion of Shaft and Platymeric Index ...	(+) − ·071 ± ·069	1·0	75	

	Right Side				Left Side				
	Character Pair	$\Delta_{♂-♀} \pm e_\Delta$	$\frac{\Delta_{♂-♀}}{e_\Delta}$	L. Order	Character Pair	$\Delta_{♂-♀} \pm e_\Delta$	$\frac{\Delta_{♂-♀}}{e_\Delta}$	R. Order	
Insignificant (*cont.*)	47. Horiz. Diameters of Head and Neck	(+) + ·074 ± ·046	1·6	27	47. Popliteal Width and Pilastric Trans. Diam....	(+) + ·047 ± ·055	0·9	90	
	48. Platymeric and Pilastric Trans. Diameters ...	(+) + ·047 ± ·032	1·5	57	48. Obliquity and Index of Bowing	(+) − ·051 ± ·067	0·8	29	
	49. Max. Length and Collar Angle	(+) + ·097 ± ·067	1·4	69	49. Torsion of Femur and Length of Shaft ...	(−) − ·057 ± ·070	0·8	32	
	50. Capito-Collar Length and Torsion of Femur ...	(−) − ·101 ± ·072	1·4	10	50. Vert. Diam. of Head and Capito-Collar Length	(+) + ·051 ± ·065	0·8	55	
	51. Pilastric Index and Index of Gracility (Lower) for Constant Pilastric Trans. Diam.	(−) − ·088 ± ·063	1·4	63	51. Length of Shaft and Pilastric Trans. Diam. ...	(+) + ·056 ± ·066	0·8	58	
	52. Torsion of Shaft and Length of Shaft ...	(+) − ·099 ± ·072	1·4	61	52. Ellipticity of Neck and Platymeric Index ...	(+) − ·049 ± ·066	0·7	3	
	53. Popl. Width and Direct A. P. Diameter ...	(+) − ·064 ± ·045	1·4	41	53. Obliquity and Collar Angle	(−) + ·043 ± ·067	0·6	35	
	54. Robusticity of Femur and Collar Angle ...	(−) + ·087 ± ·065	1·3	19	54. Capito-Collar Length and Bicondylar Width...	(+) − ·045 ± ·074	0·6	21	
	55. Vert. Diam. of Head and Capito-Collar Length	(+) + ·089 ± ·067	1·3	50	55. Capito-Collar Length and Index of Bowing ...	(+) + ·043 ± ·067	0·6	36	
	56. Popliteal Obl. and Direct A. P. Diameters ...	(+) − ·017 ± ·013	1·3	7	56. Vert. Diam. of Head and Pilastric Trans. Diam.	(+) + ·039 ± ·062	0·6	8	
	57. Torsion of Femur and Bicondylar Width ...	(+) − ·092 ± ·087	1·1	80	57. Platymeric and Pilastric Trans. Diameters ...	(+) + ·019 ± ·031	0·6	48	
	58. Length of Shaft and Pilastric Trans. Diameter	(+) + ·072 ± ·067	1·1	51	58. Torsion of Shaft and Popliteal Index ...	(−) − ·046 ± ·071	0·6	59	
	59. Torsion of Shaft and Popliteal Index... ...	(+) + ·076 ± ·072	1·1	58	59. Pilastric and Band-Radial Indices	(+) − ·051 ± ·080	0·6	86	
	60. Convexity Popl. Area and Index Popl. Skewness	(+) − ·062 ± ·058	1·1	(R. + L.)	60. Index of Bowing and Pilastric Index ...	(+) + ·031 ± ·063	0·5	81	
Markedly Insignificant	61. Obliquity and Max. Length	(−) − ·061 ± ·070	0·9	62	61. Torsion of Shaft and Length of Shaft ...	(+) − ·038 ± ·070	0·5	52	Markedly Insignificant
	62. Convexity of Popl. Area and Band-Radial Index	(−) + ·066 ± ·074	0·9	(R. + L.)	62. Maximum Length and Obliquity	(−) − ·029 ± ·068	0·4	61	
	63. Index of Bowing and Torsion of Shaft ...	(−) − ·065 ± ·070	0·9	32	63. Pilastric Index and Index of Gracility (Lower) for Constant Pilastric Trans. Diam.	(−) − ·024 ± ·059	0·4	51	
	64. Collar Angle and Capito-Collar Length ...	(−) + ·051 ± ·065	0·8	66	64. Popliteal and Bicondylar Widths	(+) + ·028 ± ·065	0·4	72	
	65. Index of Bowing and Popliteal Index ...	(−) − ·053 ± ·069	0·8	31	65. Max. Length and Bicondylar Width	(+) − ·021 ± ·062	0·3	11	
	66. Pilastric Index and Index of Gracility (Lower)	(−) − ·042 ± ·058	0·7	39	66. Collar Angle and Capito-Collar Length ...	(−) + ·020 ± ·063	0·3	64	
	67. Torsion of Femur and Platymeric Index ...	(−) − ·044 ± ·072	0·6	28	67. Diaphysial Chord and Subtense	(+) − ·015 ± ·058	0·3	40	
	68. Collar Angle and Index of Bowing	(−) + ·027 ± ·048	0·6	(R. + L.)	68. Torsion of Shaft and Pilastric A. P. Diam. ...	(−) − ·023 ± ·070	0·3	67	
	69. Torsion of Shaft and Pilastric A. P. Diameter	(−) − ·042 ± ·071	0·6	68	69. Max. Length and Collar Angle	(+) + ·012 ± ·065	0·2	49	
	70. Torsion of Shaft and Pilastric Index	(+) + ·039 ± ·070	0·6	18	70. Capito-Collar Length and Robusticity of Femur	(+) + ·013 ± ·070	0·2	73	
	71. Convexity of Popl. Area and Popliteal Index	(+) + ·031 ± ·052	0·6	(R. + L.)	71. Robusticity of Femur and Index of Bowing ...	(+) − ·017 ± ·069	0·2	46	
	72. Popliteal and Bicondylar Widths	(+) + ·037 ± ·063	0·6	64	72. Trochanteric Length and Bicondylar Width ...	(+) + ·014 ± ·065	0·2	13	
	73. Capito-Collar Length and Robusticity of Femur	(+) − ·039 ± ·071	0·5	70	73. Platymeric A. P. and Trans. Diameters ...	(+) − ·015 ± ·064	0·2	17	
	74. Max. Length and Platymeric Index	(+) − ·031 ± ·066	0·5	8	74. Platymeric and Popliteal Indices	(+) + ·010 ± ·066	0·2	85	
	75. Torsion of Shaft and Platymeric Index ...	(−) − ·039 ± ·071	0·5	46	75. Length of Shaft and Bicondylar Width ...	(+) − ·014 ± ·072	0·2	44	
	76. Obliquity and Robusticity of Femur	(+) − ·029 ± ·072	0·4	16	76. Torsion of Femur and Popliteal Index ...	(−) − ·004 ± ·072	0·1	45	
	77. Max. Length and Index of Bowing	(−) − ·022 ± ·049	0·4	(R. + L.)	77. Pilastric A. P. and Trans. Diameters ...	(+) + ·003 ± ·060	0·1	79	
	78. Torsion of Femur and Index of Bowing ...	(−) + ·029 ± ·070	0·4	44	78. Platymeric and Pilastric Indices	(+) − ·050 ± ·053	0·1	18	
	79. Pilastric A. P. and Trans. Diameters... ...	(+) + ·025 ± ·061	0·4	77	79. Oblique and Maximum Lengths	(+) + ·000 ± ·0006	0·0	43	
	80. Pilastric and Popliteal Indices	(+) + ·022 ± ·062	0·4	42	80. Torsion of Femur and Bicondylar Width ...	(−) − ·002 ± ·084	0·0	57	
	81. Index of Bowing and Pilastric Index... ...	(+) + ·028 ± ·064	0·4	60	81. Collar Angle and Length of Shaft	(+) − ·001 ± ·067	0·0	89	
	82. Convexity Popl. Area and Ind. Gracility (Lower)	(+) + ·026 ± ·060	0·4	(R. + L.)					
	83. Max. Length and Pilastric Index	(+) − ·019 ± ·068	0·3	37					
	84. Length of Shaft and Pilastric A. P. Diameter	(+) + ·017 ± ·065	0·3	43					
	85. Platymeric and Popliteal Indices	(+) − ·017 ± ·067	0·3	74					
	86. Pilastric and Band-Radial Indices	(+) + ·013 ± ·083	0·2	59					
	87. Popliteal Width and Popliteal Length ...	(+) + ·004 ± ·060	0·1	35					
	88. Convexity of Popl. Area and Band-Radial Index	(+) − ·007 ± ·074	0·1	(R. + L.)					
	89. Collar Angle and Length of Shaft	(+) − ·001 ± ·068	0·0	81					
	90. Popliteal Width and Pilastric Trans. Diameter	(+) − ·002 ± ·050	0·0	47					
	91. Pilastric and Condylar Lengths Indices ...	(+) + ·003 ± ·078	0·0	33					

The sign in brackets gives the sign of the male correlation. The sign before the difference is that of the difference: male minus female. If the sign in brackets and that which follows it agree, then the male shows preponderance in numerical intensity of correlation.

(R. + L) denotes that the sex difference was determined for correlations worked out for both right and left bones pooled.

It is difficult on this evidence to claim female predominance in correlation for more than a single pair of characters. The *less* the index of gracility, the more gracile is the bone, and since the correlation of the indices of gracility and robusticity is positive, we conclude that the more gracile a bone, the less robust is its character. This association of the absence of robusticity with gracility appears more intense in female femora.

We must now analyse the cases in which the male bones show predominance of correlation. Of the 29 cases of most probable or probable significance we note:

(a') Oblique and Maximum Lengths of External Condyle. Most probably significant for both sides. Now if we turn to Table X on p. 182 we note that the male bone is more variable than the female in all four cases of oblique and maximum lengths of external condyle and on the left side in the case of the oblique length this excess of variability rises to great importance.

(b') Vertical Diameter of Neck and Bicondylar Width most probably significant on both sides. In all four cases Table X again shows us male predominance of variation and in the case of the vertical diameter of the neck this predominance is very significant.

(c') Vertical Diameter of Neck and Oblique Length External Condyle. Most probably significant on left and possibly significant on right. This is again a case where Table X shows the marked predominance of male variation, especially on the left side for oblique condylar length.

(d') Trochanteric Length and Maximum Length External Condyle. Most probably significant on left and possibly significant on right. In the trochanteric length Table X shows that there is no significant sex difference in variability. In the maximum length of external condyle there is a somewhat greater male predominance of variability more marked on the left side.

(e') Maximum Lengths of External and Internal Condyles. Most probably significant on left and possibly significant on right.

(f') Bicondylar Width and Oblique Length of External Condyle. Probably significant on both sides. Again cases in which all characters show uniform, if not in bicondylar width marked, male predominance of variation.

(g') Vertical Diameters of Head and Neck. Probably significant on both sides. There is very marked male predominance of variation (Table X, p. 182) in both vertical diameters of head and neck.

(h') Maximum Length and Vertical Diameter of Head. Probable significance on right and possible significance on left. In the case of the maximum femoral length male variation predominates on right and female on left, both of no importance. Very significant male predominance on both sides for the vertical diameter of the head.

(i') Oblique Length and Capito-Collar Length. Probably significant on right and possibly on left. Slender female predominance of variation in both characters.

(j') Maximum Length and Capito-collar Length. Probably significant on right and possibly on left. Balanced variation in first, slight female preponderance in second character.

(k') Bicondylar Width and Maximum Length External Condyle. Probable significance on right and transition to insignificance on left (1·8). Male predominance in variation but of no marked kind in both characters.

(l') Bicondylar Width and Vertical Diameter of Head. Probably significant on right and possibly significant on left. Male predominance of variation slight in bicondylar width, marked in vertical diameter of head.

(m') Vertical Diameter of Head and Oblique Length External Condyle. Probably significant on right and possibly significant on left. Marked male preponderance of variation in three out of the four series, and slight preponderance in the fourth.

This concludes the 13 pairs of characters in which the male preponderance is at least probably significant on one side and not below possibly significant on the other. It will be seen that with the exception of (i') and (j') which involve the capito-collar length—a character insignificantly more variable in the female than the male—*the character pairs all involve measurements of the epiphyses in which there is a preponderance of male variability.*

If we turn to the remaining ten pairs of measurements falling into the most probably or probably significant classes[1], we find significant male preponderance on one side associated with insignificant reversal or female preponderance on the other side in five cases: *i.e.*

(α) Platymeric Index and Ellipticity of Neck. Right 4·0, Left 0·7 and sign reversed.

(β) Platymeric Antero-posterior Diameter and Platymeric Transverse Diameter. Right 3·1, Left 0·2 and sign reversed.

(γ) Platymeric Index and Maximum Length. Left 3·4, Right 0·5 with sign reversed.

(δ) Maximum Length and Bicondylar Width. Right 3·3, Left 0·3 and sign reversed.

(ϵ) Popliteal Oblique and Direct Antero-posterior Diameters. Left 3·9, Right 1·3 and sign reversed.

Now these pairs are peculiarly instructive; except for the bicondylar width in one case they do not contain the epiphysial measurements wherein great male preponderance of variation has been noted. But they do contain measurements in which peculiar sex differences on right and left side have been recorded. Turning to Table IX (p. 181) we note that: there is a preponderance of female variability ($-1·9$) on right side and of male variability ($+2·9$) on left side in the platymeric index; further there is a preponderance of slight male variability on the right and of female variability on the left in the ellipticity of the neck; while in the popliteal direct and oblique antero-posterior diameters (Table X, p. 182)

[1] There are 29 such measurements, 2 show female correlational excess; four pairs (8 cases) occur on both sides, 9 cases are paired with possibly significant cases, thus leaving 10 pairs of measurements to be dealt with.

there is most significant female preponderance of variability on the left side and small male significance on the right. It would thus seem that we are dealing with a group of characters which do not run in the same way in both right and left members. The reader will find this view confirmed if he examines the position of the side differences for male and female of the platymeric index and the ellipticity of neck in Table VII, p. 177, and the two popliteal antero-posterior diameters in Table V on p. 175. In these cases the side differentiation is obscuring the sexual differentiation. Until we have very much longer series it will not, we believe, be possible to separate out the exact influence of sex; we have first to account for, or at least confirm, the marked side differences.

If we turn to the remaining five pairs of characters in which both sides show the same sign, probably significant on one side and non-significant on the other, we find at once a return to the epiphysial measurements. They are:

(α') Capito-collar Length and Shaft Length. Right 3·0, Left 1·5 of same sign.

(β') Vertical Diameter of Head and Pilastric Transverse Diameter. Right 3·7, Left 0·6 of same sign.

(γ') Vertical Diameter of Head and Length of Shaft. Right 3·3, Left 1·2 of same sign.

(δ') Bicondylar Width and Trochanteric Length. Right 3·2, Left 0·2 of same sign.

(ϵ') Platymeric and Pilastric Indices. Right 3·1, Left 0·1 of same sign.

The last pair as shown by Table IX, p. 181, are very anomalous in their variability and no stress can be laid on the result.

Lastly we may pick out from the possibly significant those character pairs which show the same sign on both sides. They are:

(ζ') Maximum Length of External Condyle and Length of Shaft. Right 2·7, Left 2·6 of same sign.

(η') Vertical and Horizontal Diameters of the Neck. Right 2·3, Left 2·0 of same sign.

And close up to these

(θ') Torsion of Femur and Pilastric Index. Right 2·3, Left 1·9 of same sign.

(ι') Torsion of Shaft and Retorsion of Bust. Right 2·8, Left 1·9 of same sign.

The retorsion of bust is a character with considerable male preponderance, and the torsion of femur one with probably female preponderance. Both torsion and pilastric index show marked sexual differences: see Table VIII, p. 136, and Table IX, p. 142.

Now this analysis of the cases of male predominance seems to indicate clearly that the predominance occurs in a marked way in those epiphysial characters where the female variability is less than the male. Now let us consider the possibilities which could have produced this lessened correlation in the female bones.

(i) Selection may have acted more intensely on the male bone, directly selecting not its absolute characters, but their *correlation* with one another with a view to its greater fitness for physical functions. Were this the case the fact

that the correlations are greater precisely in those characters where the female is less variable would require explanation.

(ii) Selection may have acted on the *absolute size* of the female epiphysial characters. In so doing and reducing their variability it would have lessened their correlations. It must be remembered that the female bones being less in absolute size than the males, any errors in measuring the small epiphysial measurements are likely to be more influential in the case of the female bones. But this would, we think, tend to increase rather than decrease the apparent variability.

It appears to us that a selection of female absolute size which would tend to reduce correlation is the source of the observed male preponderance in correlation, and as we have shown in Table X, p. 182, it is precisely in the epiphyses that this preponderance of male variability in absolute size exists. It would be idle here to repeat the arguments of p. 183, which seem to us to establish the likelihood that the proximal epiphysis in the case of the female has been stringently selected owing to the need for establishing the best conditions for equilibrium in pregnancy, while the distal differences might be but are not necessarily accounted for by a post-mortem selection of the more substantial female bones, or an ante-mortem selection of the women of the working classes, who were left in the city to die of the plague. The views expressed are supported by the fact that after the epiphysial characters it is the capito-collar length and the torsion which give the most significant male preponderance of correlation and these are precisely characters which in their relation to pelvic needs are most likely to have been subject to stringent female selection.

To conclude, we cannot infer from our analysis of the preponderance of male correlation in the measurements of the femur, that it indicates that the male bone has been evolved as a fitter organ with more intensely correlated parts for its physical functions. The preponderance does not occur in the correlation of all or indeed of many pairs of characters. In fact hardly at all in pairs of characters taken from the diaphysis or from the diaphysis and one or other epiphysis. It is just what would arise if the dimensions of the epiphyses had been more stringently selected in woman than man. Such selection was we believe in our case partly periodic—post- or ante-mortem—of existing individuals but also in part secular, or arising from the evolution of the race, exhibited in the tendency to increase the efficiency of the female femur as a support during pregnancy by reducing in a marked degree the variability of its bust, and possibly in a less degree, or at least in a less definitely proven degree, the variability of the distal epiphysis.

(vi) *General Consideration of the Distribution of Correlation in the Parts of the Femur.*

(i) *Whole Bone with Whole Bone.* Starting with characters of the whole bone correlated with characters of the whole bone we should naturally expect to find and do find extremely high correlations between measurements which to a

large extent cover each other; such for example are the oblique and maximum lengths, and the oblique trochanteric and maximum trochanteric lengths, all values over ·99. Apart from such characters, features which are more or less those of the femur as a whole, for example its obliquity and torsion, have but small relations among themselves or to the absolute size of the femur. The obliquity is hardly related to the length of the femur, and what relation there is is *negative, i.e.* the shorter the femur the more oblique it is. It would thus appear that requisite breadth of the pelvis at the *acetabula* is only partially obtained in short femora by increased obliquity. This is confirmed in a general way by the correlations between the obliquity and the robusticity[1] of the femur which although positive are practically insignificant. The robusticity of the femur is measured by 100 times the sum of its pilastric diameters divided by the oblique length. A short thick femur shows increased robusticity, but this is accompanied by no sensible increase of obliquity.

The absence of any significant relation—what exists is suggestively reversed in sign in the case of the female—between length of femur and angle of torsion of femur indicates how the osteologists' measure of torsion by *total* angle is justified. The smallness and irregularity of the torsion and obliquity results demonstrate how nearly independent of each other are these two fundamental characteristics.

(ii) *Whole Bone with Proximal Epiphysis.* It would be wrong, however, to suppose that the correlation of the size of the femur with other characters is only large when the latter form considerable component parts of the size measured. The maximum and trochanteric lengths are quite considerably correlated especially in the male with the bicondylar width and still more highly with the maximum length of the external condyle. The supposition is refuted also by the considerable correlations between the size of head and size of femur. A massive or long femur does imply that certain portions of proximal and distal epiphyses are also large. That this result is not due to the epiphyses contributing certain portions (relatively small indeed) to the major femoral lengths is evidenced by

(*a*) the relatively small correlations of the capito-collar length, especially in the female, with both maximum and oblique femoral lengths, and

(*b*) the length of shaft alone being substantially correlated with the vertical diameter of the head (but *not* with the capito-collar length) and again with the bicondylar width and the length of the external condyle, which are not sub-portions of itself. The peculiar position of the capito-collar length as determined by us (see p. 197) is its small-association with the size of the femur as a whole, especially in the case of the female. It might at first sight appear that this result could only be due to unusual or defective methods of determination. But the practical

[1] Some objection has been taken to our use of the word "robusticity," on the ground that the English noun is "robustness." But we have purposely used an English form of the French *Indice de robusticité*, because we are not prepared to say that this index accurately measures the "robustness" of the femur. We prefer to use a term directly derived from M.L. *robustitas* for a new technical term, where an accepted word might have implied full acceptance of its "atmosphere."

absence of correlation between shaft length and capito-collar length (a value negative indeed in the female) is accompanied by a quite sensible correlation between capito-collar length and bicondylar width.

To throw further light on this curious point the correlations of the length of neck with diameter of head, with capito-collar length, and with length of femur as a whole were investigated. As "length of neck" we took the capito-collar length less half the vertical diameter of the head. With this definition the average length of the neck is[1]:

♂ R.	♂ L.	♀ R.	♀ L.
53·51	53·83	47·82	47·01

against the capito-collar lengths:

77·04	77·21	68·38	67·40

Thus the neck is more than two-thirds of the capito-collar length and should form the more important contributory factor in the correlation of the capito-collar length with the maximum length of the femur. If n = length of neck, h = vertical diameter of head, b = bust length or capito-collar length, and l = maximum length of femur, then all the correlations can be found indirectly from the formulae:

$$\sigma_n^2 = \sigma_b^2 + \tfrac{1}{4}\sigma_n^2 - \sigma_b \sigma_h r_{bh}, \qquad r_{nh} = (\sigma_b r_{bh} - \tfrac{1}{2}\sigma_h)/\sigma_n,$$

$$r_{nb} = (\sigma_b - \tfrac{1}{2}\sigma_n r_{bh})/\sigma_n, \qquad r_{nl} = (\sigma_b r_{bl} - \tfrac{1}{2}\sigma_n r_{hl})/\sigma_n.$$

σ_b, σ_h are given in our Table I, p. 162, and r_{bh}, r_{bl} and r_{hl} in our Table II, p. 194.

In the following table we give the values of the correlations just indicated with others already found. The table brings out very clearly why the size of head is correlated fairly substantially with the size of the femur, whilst there is only a small correlation between the capito-collar length and the size of the femur.

Correlation of Parts of Bust with Maximum Length and other characters.

Character Pair	♂ R.	♂ L.	♀ R.	♀ L.
Length of Neck and Vertical Diameter of Head ...	+ ·173	+ ·145	+ ·117	+ ·134
Length of Neck and Capito-Collar Length	+ ·980	+ ·980	+ ·987	+ ·987
Length of Neck and Length of Femur	+ ·194	+ ·112	+ ·014	+ ·005
Vertical Diameter of Head and Capito-Collar Length	+ ·366	+ ·341	+ ·277	+ ·290
Vertical Diameter of Head and Length of Femur ...	+ ·590	+ ·532	+ ·411	+ ·405
Capito-Collar Length and Length of Femur	+ ·303	+ ·214	+ ·030	+ ·086

More than two-thirds of the capito-collar length are occupied by the neck and this neck has relatively small correlation with the size of the femur, and indeed with the size of the head itself. Thus the substantial correlation of size of head and size of femur is watered down, when we add the much larger but lowly correlated neck to the head in order to form the capito-collar length. We know that both head and bicondylar width are very good measures of the size of a femur, the length of neck is now shown to be a poor measure, and this is confirmed by the fact that the correlation of capito-collar length and bicondylar width

[1] The corresponding standard deviations are: ♂ R. 6·7174, ♂ L. 6·5406, ♀ R. 6·1252 and ♀ L. 6·0262.

is only half the value of the correlation between the vertical diameter of the head and the bicondylar width. The following values indicate the relationships:

Character Pair	♂ R.	♂ L.	♀ R.	♀ L.
Vertical Diameter of Head and Bicondylar Width ...	+ ·750	+ ·770	+ ·584	+ ·654
Length of Neck and Bicondylar Width*	+ ·237	+ ·188	+ ·056	+ ·285
Capito-Collar Length and Bicondylar Width... ...	+ ·376	+ ·335	+ ·150	+ ·380
Vertical Diameter of Neck and Bicondylar Width ...	+ ·683	+ ·692	+ ·297	+ ·388

* Determined, if w = bicondylar width, from the formula:

$$r_{nw} = (\sigma_b r_{bw} - \tfrac{1}{2}\sigma_h r_{hw})/\sigma_n,$$

and the use of the already ascertained values of σ_b, σ_h, σ_n and r_{bw}, r_{hw}.

And we again see the watering effect of the low neck correlations on the total correlation of the bust with the bicondylar width. It is interesting to note that the correlations of length of neck with bicondylar width though small are larger than the correlations of the former with the femoral length. The last correlation inserted shows especially in the case of the male that a character of the neck other than the length may be highly correlated with bicondylar width. Again the vertical diameter of the neck is highly correlated with the bicondylar width in males and with the vertical diameter of the head in both males and females. It is thus closely related to what may be spoken of as good indicators of femoral size. But if the length of the neck be not correlated with size we should anticipate little correlation between the length of neck and its minimum vertical diameter. Accordingly we made a special investigation of the correlations of the capito-collar length with the minimum vertical diameter of the neck, and deduced from these by aid of the formula

$$r_{n_v n} = (\sigma_b \nu_{bn_v} - \tfrac{1}{2}\sigma_h r_{hn_v})/\sigma_n$$

where n is the length and n_v the vertical diameter of the neck, the correlation of the vertical diameter and length of neck. The following table gives our results with other values put for comparison:

Character Pair	♂ R.	♂ L.	♀ R.	♀ L.
Vert. Diameter of Neck and Vert. Diameter of Head	+ ·758	+ ·772	+ ·612	+ ·656
Vertical Diameter of Neck and Bicondylar Width ...	+ ·683	+ ·692	+ ·297	+ ·388
Vertical Diameter of Neck and Capito-Collar Length	+ ·315	+ ·352	+ ·087	+ ·096
Vertical Diameter of Neck and Length of Neck ...	+ ·171	+ ·205	− ·014	− ·010

It will be seen that the relation between length and depth of the neck is positive but small in the case of the male, and negative, but insignificant in the case of the female. In other words our two factors of the neck: vertical diameter of neck largely influenced by size of femur and length of neck very little influenced by size, are seen to be remarkably little associated with each other.

The reader who will examine our description of the determination of the coaxial point D on p. 20 will observe that our construction for the capito-collar length is absolutely independent of either face of the femur. But in most femora the line

through the coaxial point perpendicular to the standard vertical plane meets the posterior face in the near neighbourhood of the intertrochanteric ridge; on the other hand it meets the anterior face *externally* to the spiral line. The reason for this is clear: the "length of the neck" is no exact quantity, it is much larger on the posterior than the anterior face. Our capito-collar length is nearer the length on the posterior than the anterior face, and the length of the neck on the anterior face cannot be simply termed "length of neck," without regard to what is happening on the posterior face. Our "length of neck" is a geometrical rather than an anatomical conception, but it does agree fairly closely with the "length of the neck" as measured on the posterior surface. Hence when we assert that the length of the neck has very small relation indeed to the size of the femur, the reader must bear in mind the exact length to which we are referring. It is conceivable that greater or less correlation may hold for measurements more nearly corresponding to the length of neck on the anterior surface. Parsons[1] gives a measurement which he terms "length of neck," but which appears to consist of the length of neck + radius of the head, the former being taken on the anterior surface. We have already (p. 22) criticised his method of measurement. But it still seemed worth while investigating the relation between his "length of neck" less half the diameter of the head, which we think will more or less correspond to the length of neck on anterior surface, and the size of the femur as determined by its maximum length. We have pooled his right and left bones, as otherwise his data are dangerously slender for correlation work. His mean values are:

$$♂\,(R.+L.)\ 41{\cdot}08^{1} \qquad ♀\,(R.+L.)\ 35{\cdot}63$$

which compared with our values on p. 213 show, since the Rothwell femora are bigger than the London, that there is something like 12 mm. difference between the "length of neck" measured on the anterior and posterior faces of the bone.

We found the correlations between the length of neck measured on the anterior face and the maximum length of femur to be:

$$♂:\ {\cdot}320 \pm {\cdot}047 \qquad ♀:\ {\cdot}308 \pm {\cdot}061$$

These are not very high correlations but somewhat higher than those found by us for our length of neck and maximum length of femur in the case of the male, and now rising to a sensible value in the case of the female. Some light is thrown on the difference in the correlation values by considering the coefficients of variation of the lengths of neck as measured approximately on the anterior and posterior faces. They are:

Anterior Face: ♂ (R. + L.) 9·65, ♀ (R. + L.) 9·15;
Posterior Face: ♂ R. 12·55, ♂ L. 12·15, ♀ R. 12·81, ♀ L. 12·82.

Clearly the length on the anterior face is a far less variable quantity, and this might justify its general use, were it not better, as we believe, to replace

[1] The femur of the subgiant L. 63 (see our ftn. to table p. 197) and a bone R. 27 with a very anomalous length of neck which we suspect to be pathological are omitted. It may be worth while putting on record the standard deviations: ♂: 3·963 and ♀: 3·259 and the coefficients of variation: ♂: 9·65 and ♀: 9·15.

its purely appreciative estimation by a process which admits of far less personal equation, and the definition of which is absolutely independent of anterior or posterior face, although it happens to agree more closely with the latter than the former value. The total evidence seems sufficient to indicate that the capito-collar length consists of two parts: the head-factor closely correlated with the size of the femur and the neck factor which has no such close relation, especially in the case of our female series.

If the length of neck be little influenced by the size of the femur, it becomes of much interest to determine what factors really determine its size. Probably no final conclusion can be reached until we are able to compare pelvic with femoral measurements,—the breadth of the pelvis from centre to centre of acetabula has we anticipate much bearing on the matter. The suggestive correlations are:

(a) The capito-collar length and the collar angle. This is not very large (circa $-\cdot25$), but in every case significant and *negative*. In other words the steeper the neck, the shorter it is. This result is indicated photographically in Plates X and XXX. It appears directly opposed to the conclusion 11° of Parsons (p. 266, Bibl. No. 111) who states that in males the longer the "neck" (his neck + head) the larger the angle, and that there is no relation between angle and neck in females. With us the relation is somewhat more intense in females. We cannot say whether this divergence in result is due to a difference in material, to a difference in method of measurement, or more probably to Parsons' very inadequate treatment of correlation.

(b) The uniformly negative if only small correlation between the capito-collar length and the torsion of the femur. We suspect that this signifies that there is larger retorsion in the case of a long neck and so less total torsion. We are not in a position to explain the mechanical origin of this association, and we suspect that like (a) it needs a discussion of pelvic conditions.

(c) The fairly considerable and positive correlations of capito-collar length and bicondylar width. This suggests that the bust of the femur is influenced not only by pelvic conditions but also by the size of the distal epiphysis.

Now there is a somewhat important element to be considered here, namely the projection of the centre of the head beyond the midtrochlear point on the mesial side. Let this projection be p. Then it would seem needful that p should always be less than about half the bicondylar width and it is therefore probable that it is highly correlated with that width. Clearly:

$$p = s \times \sin o - c \times \sin (o + \kappa) \cos \tau$$

where s is the shaft length, c the capito-collar length, and o, τ, κ obliquity, torsion, and collar angle. Substituting the mean values to obtain approximate mean values for p, we find in mm.:

	♂ R.	♂ L.	♀ R.	♀ L.
Mean projection ...	7·668	30·718	13·099	31·471

The results are somewhat remarkable[1]. The centre of the head falls externally to the midtrochlear vertical. The amount is absolutely greater in the female than the male, and most markedly larger in the left than in the right member for both sexes. The source of this difference lies only to a small extent in the absolute differences of shaft and capito-collar lengths of right and left bones, but particularly in their great differences in obliquity and to a lesser amount in their differences in collar and torsion angles. Increase in obliquity means increase in the contribution of the shaft to the projection; and again since the sum of obliquity and collar angle is greater than 90°, increase in both of them reduces that portion of the projection which is due to the capito-collar length and requires to be subtracted. Further the torsional angle is greater on the left and thus further emphasises the difference. It would in future investigations be desirable to measure this projection which could be easily done by a simple arrangement on the osteometer, when the obliquity is taken. The correlation of p, the capital projection, and the bicondylar width should for the static equilibrium be very considerable, and is probably greater on the left than the right side. We conceive that the need for a close relationship of capital projection and bicondylar width is the source of the correlation of the latter with the capito-collar length.

No significant relation between either the obliquity or the collar angle and the length of the neck appears to exist. We correlated the "true length of neck" in the Rothwell material, *i.e.* Parsons' length of neck less his radius of head with both obliquity and collar angle with the following results, where owing to paucity of material right and left members are pooled:

Character Pair	♂ (R.+L.)	♀ (R.+L.)
Obliquity and Length of Neck ...	$-\cdot142 \pm \cdot053$	$+\cdot194 \pm \cdot067$
Collar Angle and Length of Neck ...	$+\cdot129 \pm \cdot051$	$-\cdot072 \pm \cdot066$

In both cases the female reverses the male sign of correlation. The values cannot be considered significant in the case of the collar angle. They are possibly just significant in the case of the obliquity. Accordingly a long neck is slightly associated with lessened obliquity in the male, and somewhat more markedly with increased obliquity in the female[2].

It will be seen that the neck has very little relation to those characters of the femur as a whole, which might be supposed to influence it; there is still a relation to the bicondylar width which needs analysis and explanation, but probably

[1] They embrace the most noteworthy differentiation of right and left members we have yet met with. The weight on the left knee-joint seems to be applied more laterally than on the right. Can this be associated with a differentiation in weight of the right and left sides of the body?

[2] Parsons (Bibl. 111, p. 267) states that the amount of the obliquity does not seem to vary with the length of the bone (we find it persistently negative, although insignificantly small), the angle of the neck (this is incorrect, it is significantly correlated and persistently with the negative sign) or the length of the neck (this also appears incorrect on the Rothwell material itself, although more accurate methods than Parsons' are necessary to determine it).

its associations will hardly be fully expressed and cleared up until we can study the combined system of pelvis and femora.

Before we leave the relationship of the proximal epiphysis to the whole bone, it is well to draw attention to the influence of robusticity on the neck. We have already noted that the robusticity is very slightly related to the obliquity—a short thick femur being a trifle more oblique than a long thin one,—but the relationship is somewhat more marked in the case of the bust. A short thick femur has on the average a longer capito-collar length and a smaller collar angle, and this is in keeping with the sensible negative correlation between obliquity and collar angle. One can hardly doubt a compensatory process here, which by lengthening the bust and reducing its inclination to the horizontal decreases the capital projection, and lessens the chance of the vertical force on the femoral head falling beyond the limits of the external condyle.

(iii) *Whole Bone with Shaft.* At first sight the correlations of characters of the diaphysis with features of the femur as a whole seem small and only of interest because of their insignificance, for we might have expected closer associations. Fuller examination indeed tends to confirm this view, but at the same time it must be noted that only a selection of pairs of characters has been exhibited, none of which falls into the category of features whose portions have been correlated with their wholes. To rectify any impression arising from this omission, we place here the correlation of the length of shaft with maximum length of femur.

Character Pair	♂ R.	♂ L.	♀ R.	♀ L.
Length of Shaft and Maximum Length of Femur	+ ·869 ± ·011	+ ·875 ± ·011	+ ·963 ± ·004	+ ·944 ± ·006

These results are of course high, higher, indeed, than the correlations between bicondylar width, or diameter of head and maximum length; but they are not higher than we might anticipate, recognising how large a proportion of the maximum length is covered by the shaft length. Again we have not correlated the fundamental lengths of femur with either antero-posterior or transverse diameter of the shaft. But we have correlated these with the length of the shaft, and in view of the high correlations of maximum length with its component length of shaft, we might, perhaps, draw the conclusion that the fundamental lengths of the femur will have no more important relationships than the shaft has to the transverse or antero-posterior diameters of the femur. An indirect investigation of this can be made from the coefficients of variation of the robusticity of the femur. Let d_a and d_t be the antero-posterior and transverse pilastric diameters of the femur. Then the robusticity is $100i_r$ where $i_r = (d_a + d_t)/m' = d/m'$ say, and m' is the *oblique* length. Accordingly:

$$r_{dm} = \frac{v_d^2 + v_{m'}^2 - v_{i_r}^2}{2v_d v_{m'}},$$

but:

$$v_d^2 = (\sigma_{d_a}^2 + \sigma_{d_t}^2 + 2\sigma_{d_a}\sigma_{d_t} r_{d_a d_t})/(\bar{d}_a + \bar{d}_t)^2.$$

We can thus calculate the correlation between the oblique femoral length and the sum of the pilastric diameters. We find:

	♂ R.	♂ L.	♀ R.	♀ L.
Sum of Pilastric Diameters and Oblique Femoral Length	+ ·442 ± ·038	+ ·500 ± ·035	+ ·279 ± ·049	+ ·378 ± ·045
Sum of Pilastric Diameters and Length of Shaft *	+ ·283 ± ·041	+ ·366 ± ·039	+ ·231 ± ·049	+ ·371 ± ·043

* Found if s be shaft length from: $r_{sd} = (r_{sd_a}\sigma_{d_a} + r_{sd_t}\sigma_{d_t})/\sigma_d$.

It will be seen that our conclusion would not have been wholly justified, the correlation of the pilastric diameters of the shaft are in each case greater when taken with the oblique femoral length than with the length of the shaft. The reason for this must lie in the greater association with the diameters of the shaft of those parts of the femur, namely the epiphysial portions, included in the oblique length, but not in the shaft, than in those parts common to shaft and whole femur[1]. At the same time while the size of the femur, as represented by its oblique length, is quite definitely correlated with the sum of the pilastric diameters the correlation falls considerably short of those of the *maximum* length with the diameter of the head, the bicondylar width or the length of the external condyle. It is of interest to note that the association of length of femur with pilastric diameters appears to be greater in the male than the female and greater on the left than the right side.

Returning to our Table II we will now consider for the section of the whole bone with shaft its chief insignificances. The torsion of the femur, as discussed more fully later, has no relation of any real significance to any of the three principal shaft indices, platymeric, pilastric or popliteal. The index of bowing might on mechanical grounds be supposed to be associated with the robusticity of the femur, the length of the femur, its obliquity and its torsion, and this in a marked degree. There are slight relations to be discussed more fully in the next chapter, but nothing to justify us in the assumption that bowing in the bulk of normal cases arises either from mechanical influences, or is organically closely associated with other general characteristics of the femur. Further it is true that the more robust the femur, the less its gracility (the *less* the index the greater the gracility), and the relationship is quite appreciable, but it is not of that magnitude that we can say that gracility and robusticity are in any way exclusive characters. Lastly the size of the femur is seen to have no persistent and significant relation to platymery: it has a persistent, significant, but by no means marked relation to pilastry, a long bone having slightly greater pilastric index. In short the

[1] A similar illustration of two characters of the same part having less relationship to each other than the one has to a dimension of which the second is a part occurs as we have shown in the proximal epiphysis where the vertical diameter of the neck is more closely correlated with the capito-collar length than with the length of the neck alone.

shaft is there to give body to the femur as a whole, but its exact form seems to have little close relation to the chief characters of the femur as a whole. One might imagine that the length of the shaft would produce quite a considerable effect on the torsion of the femur; it has no significant influence at all and even its insignificant correlations are reversed in sign in the two sexes.

(iv) *Epiphyses.* Passing to the next section we see that the characters of the proximal epiphysis are closely correlated together, the exception, already noted, being the length of the neck, which weakens correlations involving the capito-collar length. The reader's attention may be drawn to the fact that the two diameters of the neck are less closely correlated than each is to the corresponding diameter of the head. There is clearly no principle—like the perfecting of the Hooke's joint—tending to bring into the highest association the horizontal and vertical diameters of the neck.

Turning to the distal epiphysis we remark the same high correlation of its parts that we have referred to in the proximal epiphysis. The bicondylar width is closely related to the external condyle whether we use its maximum or oblique length. The oblique and maximum lengths of the external condyle are more closely related in the male and only slightly less closely related in the female than the vertical and horizontal diameters of the head. It must follow that the angle the condylar length makes with the standard vertical plane is restricted within very definite limits. The lengths of the two condyles are more closely associated than the two diameters of the neck, and practically as closely correlated as corresponding diameters of head and neck. The only relatively low, not absolutely low correlations are those of the horizontal and vertical band-radii. Here we should theoretically have anticipated higher values on the hypothesis that the purpose served by the radii is to give a fairly constant stretch and therefore tension to the *ligamentum laterale fibulare.* But owing to the smallness of the subjects of measurement and the difficulties of determining the band-radii accurately (see our p. 19) there may well be *some* weakening of the real correlation in the process of measurement.

The impression we reach in examining the correlations of both epiphyses is that they correspond to organs in which the proportioning of the parts has been highly selected. The remarkable point, however, about the epiphysial correlations is this, that the correlations of characters belonging respectively to the distal and proximal epiphyses is practically as high as a pair of characters from the same epiphysis. It is true that there is some weakening in the case of the female bone, probably due to a direct selection of size in the female proximal epiphysis. It is astonishing how high the correlations are between the vertical diameter of head or neck and the bicondylar width or the oblique length of the external condyle. Only the capito-collar length introducing the anomalous length of neck succeeds in reducing the high correlation of head and bicondylar width.

(v) *Shaft with Epiphyses.* When we come to the association of characteristics of the diaphysis and the epiphyses, we see this intimate relationship much weakened.

The correlation for example between the vertical diameter of the head and the pilastric transverse diameter is not nearly as intimate as that between the head and bicondylar width or condylar lengths, and the relation between the diameters of the head and the shaft length is somewhat less substantial. Much the same in magnitude is the relation of bicondylar width or length of external condyle to shaft length. These are not inconsiderable correlations, but they are far from as high as those between characters of distal and proximal epiphyses. Only one correlation so far calculated reaches the latter height, it is that between the torsion of the shaft and the retorsion of the bust—the two components of the torsion of the femur. This is a noteworthy and apparently exceptional case in which the influence of the shaft impresses itself most markedly on the bust. On the other hand the size of the shaft while moderately influencing the condyles has practically no relation to the length of the bust and only the slightest to the collar angle. Other prominent features of the shaft are practically independent of any epiphysial association; the bowing has no relation to size of bust, nor demonstrably to condylar size, nor to the collar angle nor to the ellipticity of the neck,—all quantities which might have influenced it had it been in the main due to mechanical influences. Nor does the ellipticity of the neck show any clear and appreciable relation to the platymeric index, while the pilastric index, the band-radial index and the condylar length index—three indices which have been taken by various authorities as markedly influenced by evolutionary changes and as criteria between human and apelike forms—show no sign of such considerable association as we might anticipate from their asserted developmental history. In short there is a marked relative—if far from absolute—independence of diaphysis and epiphysis.

(vi) *Shaft with Shaft.* We have 31 pairs of characters. Of these only two give values in or near the fourth or highest quarter of correlation (·75—1·00). The higher of these (·82—·91), namely the correlation of the popliteal oblique and direct antero-posterior diameters might well have been anticipated to lie in this region; this pair of diameters can hardly be considered as distinct variates, but rather as due to somewhat different methods of measuring the antero-posterior diameter. The lower of the two (·70—·75) is the correlation of the platymeric and pilastric transverse diameters, which gives a closer association than, perhaps, we anticipated, for the correlation of popliteal width and pilastric transverse diameter only falls into about the beginnings of the third quarter (·50—·75) with values from ·41 to ·51 and is less than the highest of the cross diametral correlations, that of popliteal width with popliteal direct antero-posterior diameter (·50—·61). The other cross diametral correlations, pilastric antero-posterior and transverse diameters (·26—·31) and platymeric antero-posterior and transverse diameters (·03—·24), are much lower and the latter pair markedly irregular. Sensible but still only in the first or beginning of the second quarter range of correlation are the relations of the longitudinal measurements on the shaft to transverse or sagittal diameters. Thus we have length of shaft and pilastric transverse diameter (·11—·19), diaphysial chord to diaphysial subtense (·23—·35),

popliteal length to popliteal width (·26—·34) and length of shaft to pilastric antero-posterior diameter (·25—·46, with values significantly higher in the left members). With the latter group may be associated in value (·21—·38) the correlation of length of shaft with popliteal length. As a rule diameters in the same direction are more highly correlated than those in opposite directions even if of the same section—an exception being made of those of the popliteal section. Further: lengths and diameters are less closely correlated than diameter with diameter.

Turning to other features of the shaft we notice that the three fundamental indices are all positively correlated together; the platymeric and popliteal (·10—·13) slightly, the pilastric and popliteal moderately (·15—·28) and the pilastric and platymeric substantially (·39—·55, the larger values being male). The latter settles certain points which have been long in controversy and to which we shall return in the following chapter. The index of bowing has also been correlated with the three fundamental shaft indices and gives a small but sensible correlation only with the pilastric index (·19—·26). The more bowed a femur, the greater the development of the pilaster; for photographic illustrations of extreme cases the reader is referred to Plates XXXIII and XXXIV.

The pilastric index and the index of gracility (lower) are in their extreme values such peculiarly human attributes that it was desirable to ascertain if they were at all associated. It was found that they showed a quite substantial negative correlation ($-·36$ to $-·51$, with apparent predominance on the left), a low index of gracility, *i.e.* a high degree of gracility being associated with a marked pilastric development. In case this might be assumed to arise from spurious correlations owing to the presence of the pilastric transverse in the denominator of the first and the numerator of the second index, the partial correlation of the indices for constant pilastric transverse was taken. The correlations were somewhat reduced but still quite sensible. A gracile femur has undoubtedly rather increased pilastric development. Our last shaft correlations consist of two groups of coefficients. In the first the torsion of the shaft is associated with its length and with the antero-posterior pilastric diameter, the former shows only a very slight positive correlation and the latter insignificant and irregular results. Correlated with the fundamental indices the torsion of the shaft exhibits no relation to platymeric or popliteal indices, a slight positive relation to the pilastric index and a slight negative relation to the index of bowing. In other words the more pilaster and the less bowing the more torsion there will be in the shaft.

We have already indicated the evolutionary importance of the form of the popliteal area. In the second of our last groups the convexity of this area is correlated with a number of indices. The only one which shows a substantial correlation is the popliteal index (·41—·44) and it is clear that this is rather geometrical than organic. Probably the geometrical explanation applies also to the moderate correlation of convexity with popliteal skewness. There is no sensible relation of convexity with the pyramidal popliteal index, and of the remaining

three which show very slight, if just sensible correlations we can say that the popliteal area is apelike or convex when the femur (*a*) has a high index of gracility, *i.e.* is non-gracile, (*b*) has a high soffit index, and (*c*) has a low band-radial index—all features which are more emphasised in the apes than man. These points are more elaborated in another section of this memoir.

All the shaft correlations, however, we have discussed in this section, with the exception of the first two or three cited, are of relatively small intensity, and the general impression we have formed is that the characteristics of the diaphysis are not interrelated with the same intensity of those of the epiphyses among themselves or with each other. The shaft seems to us to have been less highly developed either in the relation of its various factors to each other, or in the relation of these factors to the epiphyses. There is an interrelationship, an intimacy indeed, between the characteristics of the epiphyses, which does not appear to exist between diaphysis and either epiphysis. This average low association is as close as we have been able to get to the conception of an independent Mendelian unit. But would any one have reached that conception, who had analysed thoroughly the characteristics of a single bone of the human skeleton? Are we to suppose that the portion of a bone that develops from a single centre of ossification is an independent unit? If so how shall we explain the high relationship of the epiphyses and the low relative relationship of shaft and epiphyses? No crude system of coupling will obviate the difficulty, because there is every grade of relationship even between the characters of two parts of a bone which are relatively independent. If we go further and suppose the whole femur an independent unit, we are met by the fact that tibia and fibula as well as the pelvis are as intimately associated with the femoral epiphyses and indeed with the femur as a whole as the epiphyses with one another. Nor does the wonderfully graduated system of correlations cease at bones actually in contact; the humerus has characters closely correlated with those of the femur, the bones of the hand are not only related among themselves, but with those of the foot. Even the bones of the foot are known to be correlated with those of the head. The whole bony system has its parts interlinked by broader or by narrower limits as the case may be, and any change by selection of one organ draws in its train the selection of a whole series of correlated changes. If you select, say, by size of head of femur, the strength of a man's hip-joint, it is scarcely an exaggeration to say that you will modify to a greater or less extent every bone of his body. The human frame is not built up like a pack of cards labelled nose, mouth, arm, thigh, etc., each independent of the other. You cannot take two packs, one labelled Jew and the other Gentile, and interchanging cards between them produce a hybrid with a Jewish nose and a Gentile forehead! The nasal bones and the frontal bone are associated with a whole series of cranial characters; the cards are not uniform in size, but like an indefinitely complex jig-saw puzzle have got to fit or grow into each other under stringently limited conditions, and when this has happened—if it can happen at all—the product is neither Jewish nose nor Gentile forehead, but an

infinitely complex novelty not capable of resolution into simple descriptive categories. And the "non-happening at all" possibly throws light on the failure to hybridise which still lurks about our conceptions of species. Nor in later generations of hybrids can the bony structure revert into original components, for these components would either fail to adjust themselves or if they adjusted themselves the adjustment must be so extensive that neither would represent the original component. To illustrate by a crude but effective example we may suppose that *Homo sapiens* was fertile with *G. troglodites*, and ask how the hybrid of the hybrids could combine a human *os innominata* with a gorilla's femur. They could only function by such an immense modification of both that the thigh bone would cease to be gorilloid and the hip bone human. If it be argued that the pelvis and the femora would not be independent Mendelian units but a single unit or coupled units, then the argument can ultimately be extended downwards and upwards until the whole skeleton is a single unit or a complex of coupled units, and the hybrids must either be men or gorillas! Such a system of correlations of a single bone as is published for the first time in this chapter—a system which we know both from published and unpublished data can be extended to the whole skeleton—exhibits that bone, or indeed the skeleton, not as a patchwork of independent units capable of being shuffled like cards in a pack, not again as a system of cards some free and others rigidly clipped or coupled together, but as a system of associated characters moving within degrees of freedom determinable quantitatively, some broad and some narrow, some approaching independence, others almost causal. In our opinion there is little place for a Mendelian scheme of heredity in the skeletal form, for where it appears the hybrid will be non-viable or at best deformed, a conclusion supported in the latter case by the drift of a good deal of Mendelian research. In the correlation of characters of individual bones, or of the parts of the skeleton as a whole there will be found ample ground for study not only on the part of the anatomist but also on the side of the theorist and experimentalist in heredity.

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DRAPERS' COMPANY RESEARCH MEMOIRS

BIOMETRIC SERIES XI

A STUDY OF THE LONG BONES OF THE ENGLISH SKELETON

BY
KARL PEARSON, F.R.S. AND JULIA BELL, M.A.

TEXT

PART I, SECTION II. THE FEMUR OF MAN WITH SPECIAL REFERENCE TO OTHER PRIMATE FEMORA

CHAPTERS VII TO X, APPENDICES, BIBLIOGRAPHY AND INDICES

CAMBRIDGE UNIVERSITY PRESS
C. F. CLAY, MANAGER
LONDON: FETTER LANE, E.C. 4
ALSO
H. K. LEWIS & CO., LTD., 136, Gower Street, London, W.C. 1
WILLIAM WESLEY & SON, 28, Essex Street, London, W.C. 2
Chicago: University of Chicago Press
Bombay, Calcutta, Madras: Macmillan & Co., Limited
Toronto: J. M. Dent & Sons, Limited
Tokyo: The Maruzen-Kabushiki-Kaisha

1919

CONTENTS

CHAP.		PAGE
VII.	Part I. General and Diaphysial Femoral Characters in Man	225
	Part II. Comparison of the Femur of Man with those of other Primates	311
VIII.	Characters of the Proximal Epiphysis	345
IX.	Characters of the Distal Epiphysis. An Examination of the Dwarf Femur	387
X.	Comparison of the Femora of the Anthropoids, of Primogenial Man and of Recent Man	445

Special Tables:

I.	Measurements of the Femora of Primogenial Man and Comparatives	*Folding Table to face* 464
II.	Cromagnon and Verneau's Grimaldi Negroid Types Compared with Recent White and Negro Races	468–9
III.	General Summary of Mean Values of Femoral Characters in the Primates	*Folding Table to face* 485

Appendix I. Correlation of the Femoral Characters in Man	505
Appendix II. Femora of Fossil Lemuroids from Middle Eocene, Bridger Formation, U.S.A.	508
Appendix III. Sesamoid Bones of the Knee-Joint	512
Bibliography	513
List of Author's Names	520
Index to Authorities quoted in the Text	521
Index to Subjects	523

CHAPTER VII

SPECIAL CHARACTERS IN THE PRIMATE FEMUR

PART I. DISCUSSION OF SPECIAL FEMORAL CHARACTERS IN MAN

A. GENERAL CHARACTERS

PAGE

I. (*a*) Fundamental Lengths of the Femur 226
(*b*) Statures from Femoral Lengths 235
II. Obliquity of the Femur 239
III. Torsion of the Femur 239
IV. Pithecoid Index 245
V. Index of Robusticity of the Femur 247

B. DIAPHYSIAL CHARACTERS

VI. Platymeric, Pilastric and Popliteal Indices 252
VII. Bowing of the Femur 276
VIII. On the Curvature of the Popliteal Area 287
IX. Other Indices of Shaft 297
(*a*) Indices of Gracility (Upper and Lower), (*b*) Soffit Index, (*c*) Popliteal Pyramidal Index, (*d*) Index of Popliteal Skewness, (*e*) Indices of Sagittal Proportions.

PART II. COMPARISON OF THE ABOVE CHARACTERS IN THE FEMUR OF MAN WITH THOSE OF OTHER PRIMATES

I. Introductory 311
II. Comparison of the Absolute Size of the Femur of the Primates 312
(*a*) Maximum Length, Trochanteric Length and Diaphysial Length of Primate Femur . 312
(*b*) Epiphysial Development and Diaphysio-epiphysial Index 314
III. Bowing of the Primate Femur 317
IV. Obliquity of the Primate Femur 319
V. Midtrochlear Angle of the Primate Femur 320
VI. Torsion of the Primate Femur 321
VII. On the Diameters and Indices of the Fundamental Sections of the Primate Shaft . . 325
(*a*) Diameters and Index of the Platymeric Section 325
(*b*) Diameters and Indices of the Pilastric Section: Indices of Sagittal and Transverse Slenderness 327
(*c*) Diameters and Indices of the Popliteal Section 330
(*d*) Indices of Popliteal Shape: Soffit Index and Index of Popliteal Skewness . . 332
VIII. Indices of Gracility and Taper of the Shaft of the Primate Femur 334
IX. Proximal and Distal Breadth Ratios for the Primate Femur 338
Concluding Remarks 340

Part I. Discussion of Special Femoral Characters in Man.

A. General Characters.

I (*a*). *The Fundamental Lengths of the Femur.*

The desirability of measuring at least one fundamental length on the femur has been universally recognised, but unfortunately the chief authorities differ widely in their selection of a fundamental length and as few take all the major lengths the want of a standard length sadly impedes comparative study. The chief lengths on which stress has been laid are:

(*a*) The Maximum Length (see p. 4, (*a*)).
(*b*) The Oblique Length (see p. 4, (*d*)).
(*c*) The Trochanteric Length (see p. 4, (*b*)).
(*d*) The Maximum Trochanteric Length (see p. 4, (*c*)).
(*e*) The Trochanteric Oblique Length (see p. 7, (*e*)).
(*f*) The Diaphysial Length (Bumüller).
(*g*) Mikulicz's Length of Anatomical Axis.

The French following Broca have largely adopted the oblique length and in a French memoir when no further statement is made the femoral lengths given will almost invariably be oblique lengths. The origin of this usage is probably the idea that as a component part of stature it would be most highly correlated with stature, but as we have already indicated (p. 5) stature has been shown by one of us to be slightly more closely correlated with maximum than with oblique length[1].

Since then some writers give only the oblique length it is desirable to have formulae for passing from the oblique femoral length, f_o, to the maximum length, f_m. We have found these for our English material, but the correlation is so high that they are probably adequate in practice for other races.

The formulae are:

$$\text{♂ R.},\ f_m = 1{\cdot}023{,}24 f_o - 7{\cdot}907 \pm {\cdot}120;$$
$$\text{♂ L.},\ f_m = 1{\cdot}003{,}74 f_o + {\cdot}553 \pm {\cdot}120;$$
$$\text{♀ R.},\ f_m = {\cdot}994{,}80 f_o + 5{\cdot}802 \pm {\cdot}135;$$
$$\text{♀ L.},\ f_m = 1{\cdot}002{,}81 f_o + 1{\cdot}908 \pm {\cdot}113.$$

The probable errors are those for the determination of f_m from f_o for a single bone. If the mean of n bones be taken, the probable errors must be divided by $\sqrt{n}$. It is clear that the probable errors are well within the accuracy of measurement.

We tested these rather elaborate formulae on a considerable series of individual bones and found the estimate for a single bone came, as we might anticipate from the

[1] Oblique Length has for both ♂ and ♀ a greater coefficient in the regression equation than Maximum Length, but the errors in stature as determined from length of femur do not depend on the size of these coefficients, but on the size of $\sqrt{1-r^2}$, where r is the coefficient of correlation.

form of the results[1], to adding on to f_o the difference of the means of f_m and f_o for our series, *i.e.* to predict f_m from f_o add to f_o:

2·4 for ♂ R., 2·2 for ♂ L., 3·7 for ♀ R., 3·0 for ♀ L.

Pearson[2] in 1898 working on Rollet's rather slender French data[3]—too slender to separate R. and L. bones (50 bodies of each sex)—gave 3·3 as the difference between female maximum and oblique length and 3·2 as the male difference. The former was in good accord, if fortuitous, the latter wants reducing by 0·9 mm. Of course there may be a racial difference in this value between French and English. Parsons[4] who does not carry his means to the decimal place needful in such a case gets for $f_m - f_o$:

Rothwell: ♂ R., 3; ♂ L., 4; ♀ R., 1; ♀ L., 4;

while Warren[5] has:

Naqada: ♂ R., 3·35; ♀ R., 4·12.

These are still higher than Parsons' ♂ and ♀ R., but agree with our results in making the difference in the female greater than in the male. The results just cited are based on slender material, but they may suffice to indicate that the values we have given must not be extended to other races without caution. Our original equations will then as a rule give a somewhat better result than the difference of means, and should therefore be used for racial investigations on the *means* of series[6].

Of course the chief uses of either maximum length or oblique length are for the reconstruction of stature, or for the membral indices. As the reconstruction formulae have been given for both maximum and oblique lengths the reduction is not essential in this case, but it is very important in the case of the membral indices, when it is needful to introduce uniformity into comparative data.

The Trochanteric Length was undoubtedly introduced to get over the effect of the variability of the collar angle on the maximum length and because it is more or less feasible to determine its value on the living. Klaatsch appears to advocate its general use as the primary femoral length, and has adopted it for the calculation of a certain number of indices, which is unfortunate as it has not been adopted for similar indices by other writers. We shall shortly discuss these indices.

We are not aware that much use has been made of either maximum or oblique trochanteric lengths, but one or other is tabulated by many femoralogists. All the trochanteric lengths are highly correlated; for example, for oblique trochanteric and direct trochanteric length the values are:

♂ R., ·996; ♂ L., ·997; ♀ R., ·994 and ♀ L., ·996.

[1] Take for example ♂ L.: $f_m = f_o + ·00374 f_o + ·553$; in the second very small term we may put the *mean* value of f_o, 445·481, at least as long as we are dealing with English femora. Its value is then 1·666, giving $f_m = f_o + 2·2$ as above. This method *cannot* be extended generally to regression equations and the adding of the difference of means will often lead to erroneous results. It depends here for its validity on the closeness of the regression coefficient to unity.

[2] Bibl. 79, p. 184. [3] Bibl. 46, p. 196. [4] Bibl. 111, p. 243. [5] Bibl. 77, p. 140.

[6] Warren's ♂ R. would have $f_m = 458·6$ as judged by the equation on our p. 226 from his $f_o = 455·95$, as against 458·3, found by adding difference of English means, and 459·3 actual.

There would be no difficulty in finding reconstruction formulae for any of these major lengths were they required. In the above case it would be adequate to add to the oblique to get the direct trochanteric length the quantities:

♂ R., 2·5; ♂ L., 2·1; ♀ R., 4·1; ♀ L., 2·6.

These show, as in the case of maximum and oblique length, the same excess of R. over L. and ♀ over ♂ in the differences of the two lengths. Further, if we club R. and L. bones together, we have:

Difference of Oblique and Maximum Lengths ... ... ♂ (R. + L.), 2·3; ♀ (R. + L.), 3·35;
Difference of Oblique Trochanteric and Direct Trochanteric Lengths ♂ (R. + L.), 2·3; ♀ (R. + L.), 3·35;

or complete identity. This suggests how little the collar angle has to do with the matter, and how closely these differences depend on the obliquity of the shaft.

The Diaphysial Length is measured from the upper end of the spiral line to the middle of the upper border of the patellar surface. It has been taken by Bumüller[1] as his primary femoral length, and he proposes to deduce the oblique length from it by an increase of 16 °/₀. Reversing this process the diaphysial length would be about 367 ♂ (R. + L.) and 335 ♀ (R. + L.) for our 17th century Londoners. Actually we find 73 ♂s 378·1, 62 ♀s 347·0, or to deduce the oblique length we must use 12·6 °/₀ and 12·1 °/₀ respectively, not 16 °/₀. Bumüller[2] gives:

346 ♂ Bavarians, Diaphysial Length 384·8; 53 ♀ Bavarians, Diaphysial Length 354·7.

These may be compared with his values[3] deduced from about 350 (R. + L.) ♂ femora for the other lengths:

	Mediaeval Bavarians ♂ (R. + L.)	17th century Londoners ♂ (R. + L.)
Maximum Length ...	450·2	447·2
Oblique Length ...	445·4	444·9
Diaphysial Length ...	384·8	378·1

We have not measured the diaphysial length on the great mass of our femora, although we have taken it on the ape and on the non-adult human femora. Our nearest length to it is the shaft length, ♂ 377·1, ♀ 347·7, and thus the diaphysial length is on the average sensibly equal to the shaft length.

Bumüller's reasons for rejecting all other primary lengths in favour of the diaphysial length are given in his Chapter II (S. 15 *et seq.*), but they seem to us far from convincing. His method of taking it with the tape is also unsatisfactory from the standpoint of stature relations, if the femur is much bowed. On the other hand, an index of robusticity or those of transverse or sagittal slenderness based on the diaphysial length, certainly permit the comparison of these characters in adult and infantile femora, and this is an advantage. Further arguments in favour of the use of the diaphysial length are: (*a*) that it can be taken on more bones than the maximum length[4], (*b*) that it has less variation than the other lengths. This may be true but is not demonstrated by the methods for measuring variation adopted by Bumüller. Thus

[1] Bibl. 81, S. 139. [2] Bibl. 81, S. 84. [3] Bibl. 81, S. 19.

[4] It is strange, however, that on S. 19 Bumüller takes the maximum length on 350 and the diaphysial length on only 346 femora.

he takes 10 mm. ranges on either side of the means and finds 34·6 °/₀ of his bones lie inside this range in the case of the maximum length, 32·6 °/₀ in the case of the oblique length and 34·1 °/₀ in the case of the diaphysial length. This must mean that the standard deviations of the three lengths are nearly equal, and hence that the coefficient of variation of the diaphysial length must be about 17 °/₀ *greater*.

Bumüller passes this result by without comment, and next proceeds to measure variation by the range from minimum to maximum value, a very fallacious proceeding. He finds the range for maximum length to be 153 mm. and for diaphysial length 121 mm. On this he remarks: "Die wahre Länge des Schaftes weist also bedeutend geringere Schwankungen auf[1]." But the remark shows that he has not only disregarded the statistical principle that range is a very poor measure of variation, but also the more obvious consideration that the sizes of the varying quantities are not the same. Even the poor test of total range shows that for maximum length the variation, 3·4 °/₀ of its size, is only slightly in excess of the 3·1 °/₀ of the size in the case of diaphysial length.

Lastly, there is in many bones considerable difficulty in determining what is the upper end of the spiral line ("vom oberen Ende der *linea obliqua*," Bumüller). In the sample femur which has been on the table while this memoir was in progress, the spiral line is a centimetre broad where it joins the rugosities of the great trochanter. Bumüller does not state which point of this broad rugose belt is to be taken as the "upper end of the spiral line." The anterior face of the bone frequently runs up into a narrow neck between spiral line and great trochanter, and this neck may contain isolated rugosities of either the spiral line or the great trochanter, so that it is not easy to state at the upper end of the spiral line where the diaphysis ends. We believe it would be best to measure the diaphysial length in the following manner:

Place the bone in the standard position on the table and mark the summit of the tubercle of the femur (proximal limit, L_p); carry a thread from this summit to the mid-trochlear point and mark, when it is taut, where it meets the patellar border (distal limit, L_d). The distance L_pL_d from proximal limit to distal limit, taken with the calipers (not the tape), shall be termed the diaphysial length. In any future system of femoral measurements we should feel inclined to take this diaphysial length, and base on it a second index of robusticity, *i.e.* 100 × the sum of the pilastric diameters divided by the diaphysial length. Possibly also it might be used for the indices of sagittal and transverse slenderness in place of the length of shaft[2]. We

[1] Bibl. 81, S. 19.

[2] Suppose the sagittal plane through mid-trochlear point O and coaxial point D to meet the *anterior* border of the spiral line in S. Then L_dS would be a very fair diaphysial length, perhaps 40 mm. shorter than our revised Bumüller's measurement. But the distance DS projected on the standard vertical plane is almost equal to the distance OL_d projected on the same plane, say 1·5 to 2 centimetres in both cases. Thus our shaft length apparently terminating proximally at a point not on the epiphysial border is really a much better approach to a diaphysial length than the reader might at first sight give it credit for being. The difficulty about taking L_dS directly lies in the determination of the exact point where the sagittal plane through O and D meets the *anterior* border of the spiral line. For this reason we have selected the summit of the tubercle of the femur as a more definite limit.

could not, however, follow Bumüller in treating this diaphysial length as the paramount femoral length and neglecting for it other major lengths which seem to be essential for stature estimates and for the membral indices.

Another femoralogist, almost as suggestive as Bumüller and who has done valuable work, Mikulicz, is again unconventional in his choice of a paramount femoral length. As far as we are aware he has found no followers in the thirty-nine years that have elapsed since the publication of his paper[1]. Mikulicz replaced the mid-trochlear point *O* by an intracondylar point *b*, taken midway between the points in which the condyles touch the standard horizontal plane[2]. He joins this point to the summit *a* of the great trochanter and apparently assumes the line *ab* to pass through the coaxial point *m*= our *O*. Further let *n* be the spherical centre of the head and *bn* meet the surface of the head in *c*, and *mn* meet the head in *e*. Then *me* corresponds to our capito-collar axis, *mn* to our length of neck. Mikulicz terms *cb* the "mechanical axis" of the femur and *ab* the "anatomical axis." He terms the mechanical axis the measure of the femur (*Maass für das Femur*). *bm* is Mikulicz's length of shaft and *am* his height of great trochanter. A little consideration will show that Mikulicz's length of anatomical axis must be almost the mean of our trochanteric length and of our maximum trochanteric length. We are thus able to deduce the following values for Mikulicz's measure in the case of our London bones :

Length of Anatomical Axis.

♂ R., 430·58 ; ♂ L., 429·83 ; ♀ R., 393·63 ; ♀ L., 393·24.

The mean total length of femur + tibia for Mikulicz's material appears from the data on his S. 365—6 to have been 793·2 mm. He further tells us (S. 254) that the proportion of the femur was in the mean 56·4 to 100 of the combined tibio-femoral length. Hence his mean mechanical axis was 447·36 mm. But he further gives on S. 370 a table of the angle between his mechanical axis and his "knee-basis." The mean value of the angle there recorded is 86° 39′. Accordingly the oblique length of his femora which should be the perpendicular from the top of his mechanical axis on his knee-basis = 447·36 × sin 86° 39′ = 446·60. Now his material consisted of bones from the bodies sent to the dissecting rooms of three Viennese hospitals, and he particularly says that he does not know anything about the sexes and has not endeavoured to separate them. The above value of the oblique length would correspond well with Bumüller's Bavarians (see our p. 228), if it consisted only of male bones. But if it consisted of the two sexes in fairly even numbers the mean[3] length of the male femur must have been about 467 mm., which is a very high value for the mean oblique length of a male femur. We should be surprised to find a value above 460 at most for such a hospital population. Hence it seems probable that Mikulicz either selected the better or larger 100 of his 200 bones to work with, or that the bulk of the

[1] Bibl. 22, S. 351 *et seq.*

[2] Mikulicz does not closely describe how *b* is to be determined. He uses a lamp-blacked standard horizontal plane to mark the points of contact of his condyles, and he terms the distance between these blackened points the "knee-basis"—"auf welcher man sich Femur und Tibia in Berührung zu denken hat," *loc. cit.* S. 354.

[3] The female femur would be about 8·8 °/₀ less than the male in oblique length : see our p. 145.

bodies were male. In which case his data would agree well with Bumüller's result. Still his material seems to have been tall. For, remembering that his anatomical axis is 447·36 and that the maximum trochanteric length exceeds the trochanteric length by about 8·7 mm., we can reverse the process by which we have reached the anatomical axis of our Londoners, and we find the maximum trochanteric length of Mikulicz's Viennese to be 451·7. Again the maximum length exceeds the trochanteric by about 12·0 mm., so that Mikulicz's population would have a maximum length of about 464, considerably in excess of our Londoners or indeed of Parsons' Rothwell femora. The same point is illustrated by comparing his length of shaft = 48·7 × 793·2,—*i.e.* Mikulicz's proportion (S. 363) of shaft × by his tibio-femoral length,— = 386·3, which less 1·5 cm. for distance from his intracondylar point to our mid-trochlear point gives 371 for his measurement of what we term the shaft length, and has to be compared (supposing a moiety of each sex) with 362 for our Londoners. Finally we can obtain from Mikulicz's data the length of neck, vertical diameter of head and pilastric transverse; they give the following results, always assuming the sexes equally distributed:

	17th century Londoners	19th century Viennese
Length of Neck ...	50·5	54·7
Diameter of Head ...	43·9	48·4
Pilastric Transverse	26·6	28·6

The differences are so considerable on this hypothesis that although we must admit the Viennese to be the bigger, we are still compelled to hold that the bulk of Mikulicz's material must have been male[1].

While Mikulicz's mechanical axis is possibly of importance for a study of the tibio-femoral relations, it is a great drawback that he has given no absolute means, but only proportions, carried to *one* decimal per cent., of other characters in terms of his tibio-femoral length. Further his disregard of sex and side still further reduces the value of his data for comparative purposes. Lastly his individual "measurement of the femur" renders his tibio-femoral index of less value than it would otherwise be for interracial studies, wherein as a rule more customary lengths have been taken as the basis of the ratio.

Trochanteric Lengths. While quite a number of writers have recorded one or other trochanteric length, few, notwithstanding a good deal of advocacy of its advantages[2], have turned the recorded values to any real use. Among these few Klaatsch must be particularised. He has adopted the trochanteric length as the basis of three indices. These indices are:

(α) 100 × Breadth of Proximal Epiphysis / Trochanteric Length. This we initially rejected on the ground that the distance from the great trochanter to the mesial face of the head was not a satisfactory measurement, being largely dependent on the cervical

[1] Our capito-trochlear length is 432 for males (R. + L.) and 394 for females (R. + L.). Adding 15 mm. for distance from mid-trochlear point to intracondylar point of Mikulicz we reach ♂ 447, ♀ 409 for Mikulicz's "mechanical axis" in our London femora. The former is identical with Mikulicz's value, but the combined sex value 428 is so far below his value as to confirm the view that his material was largely male.

[2] For example, that it frees the fundamental length from variations in the neck and head, that it is more of an anatomical unity than the maximum length, that it is more accessible in the living, etc.

angle and compounded of parts anatomically differentiated. Later we determined it for 135 femora.

(*b*) 100 × Breadth of Distal Epiphysis/Trochanteric Length, and

(*c*) 100 × Length of External Condyle/Trochanteric Length.

(*b*) and (*c*) we have recorded. We propose in this section to compare our values for (*a*) and (*b*) with such material as we have been able to put together from other sources. Klaatsch gives unfortunately scarcely more than individual values[1] for (*a*) and (*b*) and uses the inverse of the ratio multiplied by ten, *i.e.* although he says: "druckt man die Proportion der distalen Breite zur Trochanteren Länge zahlenmässig aus," he actually divides the trochanteric length by the bicondylar width and repeats this process with the length of the external condyle for (*c*). The table on the following page has been obtained from a few of our own measurements, but principally from those of Klaatsch and Prochownick[2]. The latter gives only the proximal breadth and the maximum not the trochanteric length. If we call the index the *Proximal Breadth Ratio*, we have, based upon a slight modification of our ratio of maximum to trochanteric length in Londoners[3]:

Proximal Breadth Ratio (for trochanteric length) = 1·04 × Proximal Breadth Ratio (for maximum length), or inverted Proximal Breadth Ratio (for maximum length) = ·962 × Proximal Breadth Ratio (for trochanteric length).

Several important points flow from the table on p. 233:

(*a*) There is nothing as far as it extends to indicate any advantage in using trochanteric instead of maximum length in forming the index. Where we can get an index in both ways the calculated value is for all practical purposes as good as the observed[4].

(*b*) The only racial differentiations to be noted here are (i) the separation of *Homo primogenius* and (ii) probably the Australians from modern civilised and modern primitive man.

(*c*) As in several other cases we have dealt with, *Homo primogenius* and the Australians are on *opposite* sides of modern civilised man and of most of the modern primitive races. Whatever may be claimed for the skull the Australians are not for the femur closer to *Homo primogenius* than to modern civilised man.

(*d*) As in many other features there is nothing to distinguish the Trinil femur from that of modern man.

(*e*) This index, at any rate for the small numbers provided by Klaatsch[5], seems

[1] Bibl. 87, SS. 651—3, 657.

[2] Bibl. 43, Table I.

[3] We should not expect very close results if these formulae be applied to the apes.

[4] It may be asserted that the trochanteric length can be more often taken than the maximum length. This is contrary to our experience given in Table I, p. 115. The great trochanter is on the whole more likely to be damaged than the head in disinterred adults. When the head is damaged the maximum length can then be fairly accurately reconstructed from the trochanteric length.

[5] It is difficult to understand what Klaatsch proposed to deduce from his tables of this index. He gives the individual indices of *five* Badenser, many other Europeans were at his command. He picks out *five* Viti Islanders out of Prochownick's 31, *five* Australians out of Prochownick's 8 (he does not confine himself to one sex, and he has misread oblique length for maximum length in at least one case) and *three* Caroline Islanders out of Prochownick's 12. He gives no reasons for these selections, nor the means of his individual cases. Almost any conclusions could be drawn by such selection, and when drawn would be wholly illegitimate. Yet this is by no means a unique illustration of anthropometric work in Germany in the twentieth century!

quite incapable of differentiating the bulk of human races. If it is of any value at all its value could only be ascertained after it had been applied to far longer series. The range of Klaatsch's Badenser or of Prochownick's Viti Islanders covers individually nearly the whole of the racial means provided except *Homo primogenius* and the Australians.

In conclusion we do not believe that this index is anatomically of any special importance. It is largely dependent on the individual rugosity development of the great trochanter, and the proximal breadth is a very heterogeneous quantity and difficult to measure accurately.

TABLE I. *Proximal Breadth Ratio**.

Race and No.	On Trochanteric Length		On Maximum Length	
	Found	Calculated from M. L.	Found	Calculated from T.L.
Gorilla (7)	27·06	27·92	26·85	26·03
Chimpanzee (2)	22·15	22·65	21·78	21·31
Orang-utan (5)	27·50	26·50	25·48	26·46
Gibbon (3)	15·10	15·44	14·85	14·53
Dryopithecus rhenanus (Eppelsheim)	17·60	—	17·42	16·93
Pithecanthropus erectus (1) ...	21·46	21·49	20·66	20·64
Neanderthal (2)	24·88	24·96	24·00	23·93
Spy (2)	26·83	26·60	25·58	25·81
Homo mousteriensis (*Hauseri*) (1) ...	24·79	24·76	23·81	23·85
Galley Hill (1)	—	24·55?	23·61?	—
Javanese (1) Kl.	23·50	—	—	22·60
Japanese (1) Kl.	22·31	—	—	21·46
Veddah (1) Kl.	22·12	—	—	21·28
American Indians (2) Kl.	22·11	—	—	21·27
17th century Londoners (135) ...	22·09	21·84	21·00	21·25
Malay (1) Kl.	21·71	—	—	20·89
Gilbert Islanders (3) Kl. & Pr. ...	—	21·44	20·42	—
Badenser (5) Kl.	21·36	—	—	20·55
Fuegians (Ona and Yaghan) (8) H.	21·24	21·25	20·43	20·43
Viti Islanders (31) Pr.	—	20·81	19·82	—
Negrito (1) Kl.	20·51	—	—	19·73
Caroline Islanders (12) Pr. ...	—	20·59	19·80	—
Hindoos (3)† Kl.	18·23	—	—	17·54
Australians (8) Pr.	—	18·21	17·34	—

* Allowance has to be made for the standard lengths used by various writers. Contractions as in following table.

† Quite unreliable, two out of three femora are from one skeleton with a very low index value.

We now turn to the Distal Breadth Ratio and treat it in like manner.

Now this table for the Distal Breadth Ratio suffices to indicate that exactly as in the case of the Proximal Breadth Ratio there is no advantage in using the trochanteric instead of the maximum length. The index as calculated from one or the other suffices to obtain the corresponding value with all requisite accuracy.

In regard to modern man, wild or civilised, both here and in the previous index larger series would be required to emphasise the nature of the interracial differences,

TABLE II. *Distal Breadth Ratio**.

Race and No.	On Trochanteric Length		On Maximum Length	
	Found	Calculated	Found	Calculated
Gorilla (7)	24·63	25·57	24·59	23·69
Chimpanzee (2)	22·25	22·91	22·03	21·40
Orang-utan (5)	22·90	22·06	21·21	22·03
Gibbon (3)	13·15	13·57	13·05	12·65
Dryopithecus rhenanus (Eppelsheim)	14·50	14·89	14·32	13·95
Pithecanthropus erectus (1)... ...	17·39	17·37	16·70	16·73
Neanderthal (2)	20·52	20·65	19·86	19·74
Spy (1)	21·95	22·29	21·43	21·12
Homo mousteriensis (*Hauseri*) (1)	22·49	22·56	21·69	21·64
Galley Hill (1)	—	21·58	20·75?	—
Japanese (20) Kog....	20·56	20·20	19·42	19·78
Javanese (1) Kl.	20·50	—	—	19·72
Aino (36) Kog.	20·13	20·05	19·28	19·37
Gilbert Islanders (3) Kl. & Pr. ...	19·76	—	—	19·01
Anau, North Kurgan (2) Mol. ...	19·45	19·02	18·34	18·71
Fuegians (15) Mar. & H.	19·36	19·45	18·70	18·62
Maori (10) Mol.	19·17	19·05	18·32	18·44
,, (21) Mol. & Hep.	—	18·72	18·00	—
American Indians (2) Kl.	19·06	—	—	18·34
Laplanders (4) Hep.	—	18·90	18·17	—
17th century Londoners ♂ R. (135)	18·82	18·84	(152) 17·94	17·92
17th century Londoners ♂ L. (148)	18·72	18·63	(161) 17·74	17·82
17th century Londoners ♀ R. (93)	18·22	18·18	(99) 17·31	17·35
17th century Londoners ♀ L. (104)	18·05	18·05	(112) 17·19	17·18
Modern British (36) Hep.	—	18·78	18·06	—
Swiss Alemanns ♂ (c. 88) Sch. ...	—	18·63	17·91	—
,, ,, ♀ (c. 88)	—	18·21	17·51	—
Modern Swiss (21) Sch.	—	18·58	17·87	—
Malay (1) Kl.	18·54	—	—	17·83
Caroline Islanders (12) Pr. ...	—	18·50	17·79	—
Sandwich Islanders ♀ (4) Hep. ...	—	18·44	17·73	—
Eskimos (4) Hep.	—	18·40	17·69	—
Veddah (1) Kl.	18·35	—	—	17·65
Andamans (11) Hep.	—	18·26	17·56	—
Viti Islanders (31) Pr.	—	18·09	17·40	—
Modern Badenser (8) Kl.	18·06	—	—	17·37
Negrito (1) Kl.	17·95	—	—	17·27
Bajuvars, Swabians and Alemanns from Row Graves (c. 16) L.-N.	17·52	17·66	16·98	16·85
Hindoos (8) Kl. & Hep.	—	17·44	16·77	—
Negroes (9) Hep.	—	17·42	16·75	—
Australians (22) Hep. & Pr. ...	—	17·15	16·49	—

* Material has been drawn from a considerable number of authorities, whose names are indicated at the side (Kl. = Klaatsch, H. = Hultkrantz, Hep. = Hepburn, Mol. = Mollison, Kog. = Koganei, L.-N. = Lehmann-Nitsche, Pr. = Prochownick, Sch. = Schwerz, Mar. = Martin); we have had to correct in many cases for the standard lengths used by these writers. Neither the Proximal nor Distal Breadth Ratio is tabled directly by any of them, and we are responsible for the calculation of the indices and determinations of the mean values.

although it is clear that modern Europeans occupy an intermediate position between Asiatics and Negroes and Australians. The primitive Australians are again separated by modern Europeans from both *Homo primogenius* and the apes. The Trinil femur fits in best with modern man, and is markedly removed from those of Primogenial man and the anthropoids. This again raises a suspicion that the Trinil femur and the skull of *Pithecanthropus erectus* were not parts of the same individual.

I (*b*). *Statures from Femoral Lengths.*

As we have already indicated (p. 5) one of the chief interests of the major femoral lengths is the reconstruction of stature. In the present instance we have used the oblique femoral length to obtain an appreciation of racial stature, because so many authorities, especially the French, only furnish this major length[1]. In a great number of cases the data are extremely sparse, the locus of origin of the femora is not stated or only inadequately stated, *e.g.* "Negroes," "Hindoos," "Chinese," "Turks." Thus some of the figures given are distinctly unreliable and their race is ill-defined. We have had in a considerable number of cases to pool material from a variety of sources and to reduce the measurements recorded to oblique length. In other cases the recorder merely states the total number of male and female bones in his series, but fails to give the exact number of either male or female bones on which his mean oblique femoral lengths are based, these alone and no individual measurements being provided. We can therefore suggest no relative weight to be given to the values provided in the table which follows[2]. Still the table may be of interest till something more accurate is forthcoming. It is based on data for the femoral length given by numerous authors, in particular Rodriguez, Hepburn, Lehmann-Nitsche, Schwerz, Bumüller, Martin, Parsons, Koganei, Scott and others, as well as our own measurements. We have added the estimates of stature determined by Pearson in his memoir of 1898 (*Phil. Trans.* 192 A, pp. 242, 3) from four long bones, and the values he gives for various races as determined by anthropometers on the living. Where the letter F_0 is placed after the stature it means that the value has been determined from the oblique length of the femur only. Where no such letter appears the humerus, tibia and radius have also where available contributed to the determination of stature. If as we hold femoral reconstructions of stature are more reliable than the measurements of travellers, who may only select or be introduced to the bigger and finer natives, it would seem that a good many of the estimates provided by early travellers require modification.

[1] For the requisite reconstruction formula, see our p. 5 above.

[2] One author will state that his material embraces 600 femora, but internal evidence may show that he considers it adequate to take his means on thirty individuals and publish no individual measurements. Another will state that he is dealing with 240 neolithic femora; possibly this number was available in large part for the pilastric index, but one may gravely doubt whether the measurement of the oblique length was possible in a quarter of this number. Serious responsibility rests with those authorities who publish merely means and not individual measurements, and still more on those who do not state the total number on which each mean is based. We have had to reject the results of several memoirs where this state of affairs is predominant, because we could only suspect from indirect evidence that the means were based on too slender numbers to be racially characteristic, or were vitiated by arithmetical blunders which could not be tested.

TABLE III. *Racial Statures.*

Index No.	Race	Authority for Data	Reconstruction from Long Bones		Measurements on the Living		Sex Ratio ♂/♀	Remarks
			♂	♀	♂	♀		
1	12 Giants (> 200)	Pearson	217·6	—	—	—	—	—
2	4 Sub-giants (Bavarian Recruits)	Ranke	—	—	190·5	—	—	—
3	3 Sub-giants (Museum Specimens)	Pearson	186·9	—	—	—	—	—
4	Samoans	Topinard	—	—	188·3	—	—	—
5	Patagonians	Moveno & Lister	—	—	185·0	—	—	See No. 36
6	Caribeans	Humboldt	—	—	184·0	—	—	See No. 105
6 *a*	Cromagnon	Rodriguez	175·7	—	—	—	—	From 13 femora: see No. 29
7	Red Indians	Topinard	—	—	175—180	—	—	See No. 36
8	Polynesians	Topinard	—	—	170—180	—	—	See No. 55
9	Flamborough Head English	Pitt-Rivers	—	—	175·2	162·5	1·078	—
10	Livonians	Topinard	—	—	173·6	—	—	—
11	Americans (born)	Gould	—	—	173·5	—	—	—
12	Fellahs (Egypt)	Wolney	—	—	173·0	—	—	—
13	English (Middle Class)	Pearson	—	—	172·8	159·9	1·080	See Nos. 25, 47, 68
14	Todas of Nilgherry	Marshall	—	—	172·7	—	—	—
15	Norwegians	Hunt	—	—	172·0	—	—	See No. 19
16	American Scottish	Gould	—	—	171·6	—	—	—
17	Bantu	Fritsch	—	—	171·8	—	—	—
18	Finns	Bonsdorff	—	—	171·4	—	—	—
19	American Norse	Baxter	—	—	171·3	—	—	See No. 15
20	Round Barrow British	Pearson	171·1	160·2	—	—	1·090	—
21	Anglo-Saxons	Pearson	170·9	156·0	—	—	1·096	—
22	American Irish	Gould	—	—	170·5	—	—	—
23	Lithuanians	Topinard	—	—	170·4	—	—	—
24	American English	Gould	—	—	170·1	—	—	See Nos. 13, 25
25	English Commonality	Galton	—	—	170·0	158·3	1·074	See Nos. 13, 24
26	Sikhs	Topinard	—	—	170·0	—	—	—
27	Bajuvars from Row Graves	Lehmann-Nitsche	169·2	154·5	—	—	1·095	♂ 169·9 (F_o), ♀ 155·4 (F_o)
28	Australians	Hepburn	169·7 (F_o)	152·6 (F_o)	—	—	1·112	—
29	Cromagnon	Pearson	169·6 (F_o)	—	—	—	—	Estimate of F_o from diaphysial caste length: see No. 6 *a*
30	American Germans	Baxter	—	—	169·5	—	—	See Nos. 41, 59, 60, 62
31	Swabians and Alemanns from Row Graves	Lehmann-Nitsche	169·2 (F_o)	152·3 (F_o)	—	—	1·111	See Nos. 35, 59
32	American Danes	Baxter	—	—	169·2	—	—	See Nos. 15, 19
33	American Swedes	Gould	—	—	169·2	—	—	See Nos. 15, 19
34	Nubians	Topinard	—	—	169·0	—	—	See Nos. 12, 43
35	Swiss Alemanns	Schwerz	—	—	168·8	154·7	1·091	See Nos. 31, 62
36	Patagonians	Rodriguez	168·8 (F_o)	153·9 (F_o)	—	—	1·097	See No. 5
37	Bechuanas	Fritsch	—	—	168·4	—	—	—
38	Ancient Gauls	Rodriguez	168·0 (F_o)	154·0 (F_o)	—	—	1·091	See No. 75
39	American Negroes (pure)	Gould	—	—	168·0	—	—	See Nos. 17, 43
40	4th to 9th century Mediaeval French	Rahon & Pearson	168·0	154·8	—	—	1·085	See Nos. 52, 54, 56, 61
41	Modern German (locus?)	Rodriguez	167·8 (F_o)	?	—	—	—	See Nos. 30, 59, 62
42	Modern British	Hepburn	167·7 (F_o)	—	—	—	—	See Nos. 24, 47,
43	Negroes (locus?)	Rodriguez	167 5 (F_o)	153·4	—	—	1·092	See Nos. 17, 39
44	Naqadas (Prehistoric Egyptians)	Warren	167·5	156·0	—	—	1·074	See Nos. 12, 34
45	Neolithic Man in Britain	Pearson	167·3	—	—	—	—	See Nos. 74, 75 *bis*, 85, etc.

Index No.	Race	Authority for Data	Reconstruction from Long Bones		Measurements on the Living		Sex Ratio ♂/♀	Remarks
			♂	♀	♂	♀		
46	Kabyles	Prengrüber	—	—	167·3	—	—	—
47	Rothwell Mediaeval English	Parsons	167·0 (F_o)	152·2 (F_o)	—	—	1·097	Sex-ratio large for modern man
48	*Pithecanthropus erectus*	Pearson	166·8 (F_o)	—	—	—	—	From photographs
49	Guanches I	Pearson	166·8	154·7	—	—	1·078	See Nos. 57, 63
50	Romano-British	Pearson	166·7	152·2	—	—	1·090	See No. 65
51	Franks	Pearson	166·4	152·1	—	—	1·091	See No. 56
52	Modern French (I)	Rodriguez	166·3 (F_o)	158·3 (F_o)	—	—	1·051	See No. 71
53	Modern French (taken on corpse)	Rollet	—	—	166·26	154·02	1·079	See Nos. 52, 71
54	10th to 11th century Mediaeval French	Pearson	166·24	154·49	—	—	1·077	See Nos. 52, 56
55	Polynesians	Rodriguez	166·2 (F_o)	154·5 (F_o)	—	—	1·076	See No. 8
56	Franks and Merovingians	Rodriguez	166·2 (F_o)	154·0 (F_o)	—	—	1·079	See Nos. 51, 52, 53
57	Guanches II	Pearson	166·2	153·8	—	—	1·081	See Nos. 49, 63
57 *bis*	Caverne de l'Homme Mort	Rahon	166·1 (F_o)	152·8 (F_o)	—	—	1·087	—
58	Moldevins	Topinard	—	—	166·0	—	—	—
59	Bavarians (Munich district)	Ranke	—	—	166·0	—	—	See Nos. 60, 62
60	Bavarians (taken on corpse)	Bischoff	—	—	165·9	153·9	1·078	See Nos. 59, 62
61	Mediaeval French	Rodriguez	165·8 (F_o)	153·6 (F_o)	—	—	1·079	See Nos. 52, 53, 71
62	Bavarians	Bumüller	165·7 (F_o)	—	—	—	—	See Nos. 59, 60
62 *bis*	Portuguese	Tamagnini	165·6 (F_o)	150·8 (F_o)	1·645	—	1·098	—
63	Guanches III	Rodriguez	165·6 (F_o)	155·0 (F_o)	—	—	1·068	See Nos. 49, 57
64	Great Russians	Topinard	—	—	165·5	—	—	See No. 77
65	Romano-British	Hepburn	165·5 (F_o)	—	—	—	—	See Nos. 50, 75
66	Algeria, Dolmen People	Pearson	165·5	152·6	—	—	1·085	See Nos. 72 *bis*, 81
67	Melanesians	Rodriguez	165·5	153·4	—	—	1·079	See Nos. 43, 55
68	17th century Londoners	Pearson & Bell	165·4 (F_o)	152·2 (F_o)	—	—	1·087	See Nos. 13, 25, 47
69	India, Dolmen People	Pearson	165·24	154·86	—	—	1·067	See Nos. 66, 72 *bis*, 81
70	Canary Islanders	Rodriguez	165·2 (F_o)	152·4 (F_o)	—	—	1·084	See Nos. 49, 57
71	French Conscripts	Manouvrier	—	—	165·0	—	—	See Nos. 52, 53
72	Italians of Tuscany	Topinard	—	—	165·0	—	—	See Nos. 95, 100
72 *bis*	Dolmens in France	Manouvrier, Rahon	165·0 (F_o)	147·1 (F_o)	—	—	1·121 (!)	See Nos. 66, 81
73	Veddahs	Rodriguez	165·0 (F_o)	—	—	—	—	See No. 117
74	Neolithic Europeans	Rodriguez	164·9 (F_o)	152·2 (F_o)	—	—	1·083	See Nos. 45, 75 *bis*, 85, etc.
74 *bis*	Modern French	Rahon	164·8 (F_o)	150·2 (F_o)	—	—	1·097	See Nos. 52, 53
75	Romano-Gauls	Pearson	164·8	152·3	—	—	1·082	See Nos. 38, 65
75 *bis*	Neolithics, Châlons-sur-Marne	Manouvrier	164·8 (F_o)	152·2 (F_o)	—	—	1·083	See Nos. 45, 74, 75 *bis*, 81 *bis*
76	Moriori	Scott	164·6 (F_o)	153·9 (F_o)	—	—	1·070	—
77	Ancient Slavs	Rodriguez	164·5 (F_o)	153·0 (F_o)	—	—	1·075	See No. 64
78	Chinese	Brigham	—	—	164·5	—	—	See No. 108
79	Esthonians	Topinard	—	—	164·2	—	—	—
80	Ruthenians	Topinard	—	—	164·0	—	—	—
81	Caucasus, Dolmen People	Rahon	164·3	152·5	—	—	1·078	See Nos. 66, 69, 72 *bis*, 81
81 *bis*	Neolithics of Martigny	Manouvrier	164·2	150·9	—	—	1·088	See Nos. 45, 75 *bis*, 85, etc.
82	Neanderthal Man	Pearson & Bell	163·8 (F_o)	—	—	—	—	See Nos. 93, 120
83	Phoenicians and Carthaginians	Rodriguez	163·7 (F_o)	151·3 (F_o)	—	—	1·082	—
84	"Ancient Egyptians"	Rodriguez	163·4 (F_o)	155·1 (F_o)	—	—	1·054	See Nos. 12, 44
85	Neolithic Man (Mureaux)	Manouvrier	163·4	152·6	—	—	1·071	See Nos. 75 *bis*, 81 *bis*, 85, etc.
86	Maori	Hepburn, etc.	163·4 (F_o)	152·8 (F_o)	—	—	1·069	—

Table of Racial Statures (continued).

Index No.	Race	Authority for Data	Reconstruction from Long Bones		Measurements on the Living		Sex Ratio ♂/♀	Remarks
			♂	♀	♂	♀		
87	Conscript Badenser	Ecker	—	—	163·0	—	—	See Nos. 41, 59
88	Palaeolithic Man	Pearson	162·7	—	—	—	—	See Nos. 6 *a*, 29
89	Bronze Age Europeans	Rodriguez	162·5 (F_o)	147·1 (F_o)	—	—	1·105	—
90	Neolithic Man, France and Belgium	Rahon & Pearson	162·5	151·4	—	—	1·073	See Nos. 74, 75 *bis*, 81 *bis*, etc.
91	North American Indians	Rodriguez	162·1 (F_o)	148·8 (F_o)	—	—	1·089	See Nos. 7, 105
92	Fuegians	Martin and others	162·1 (F_o)	151·2 (F_o)	—	—	1·072	—
93	Man of Spy	Pearson	162·0	—	—	—	—	See Nos. 82, 120
94	Poles	Topinard	—	—	162·0	—	—	—
95	Italians from Piedmont	Topinard	—	—	162·0	—	—	See No. 100
96	Turks	Rodriguez	161·9 (F_o)	—	—	—	—	—
97	Eskimos	Hepburn, Rodriguez	161·6 (F_o)	152·9 (F_o)	—	—	1·057	See No. 109
98	Basques	Rodriguez	161·4 (F_o)	—	—	—	—	—
99	Malays	Rodriguez	161·1 (F_o)	147·9 (F_o)	—	—	1·089	—
100	Sicilians	Topinard	—	—	161·0	—	—	See No. 95
101	Neolithic Man, Breuil	Manouvrier	160·9	150·7	—	—	1·068	See Nos. 74, 75 *bis*, 90, etc.
102	Indo-Chinese	Rodriguez	160·7 (F_o)	152·7 (F_o)	—	—	1·052	See Nos. 104, 108, 119
103	Hottentots	Fritsch	—	—	160·4	—	—	—
104	Hindoos	Hepburn & Rodriguez	160·0 (F_o)	152·7 (F_o)	—	—	1·048	Caste?
105	South and Equatorial American Indians	Rodriguez	160·0 (F_o)	147·4 (F_o)	—	—	1·085	See Nos. 5, 6
105 *bis*	Neolithics (Chamblands)	Schenk	160·0 (F_o)	150·0	—	—	1·067	See Nos. 74, 75 *bis*, 90, 101
106	Samoyedes	Topinard	—	—	159·0	—	—	See Nos. 97, 109, 118
107	Annamites	Topinard	—	—	158·9	—	—	See No. 119
108	Chinese	Rodriguez	158·8 (F_o)	151·2 (F_o)	—	—	1·050	See Nos. 78, 102
108 *bis*	Prehistoric Columbians	Antony & Rivet	158·5 (F_o)	145·4 (F_o)	—	—	1·090	—
109	Eskimos	Sutherland	—	—	158·5	152·8	1·036	See No. 97
110	Sardinians	Topinard	—	—	158·0	—	—	See Nos. 95, 100
111	Japanese	Koganei & Rodriguez	157·9 (F_o)	146·3 (F_o)	—	—	1·079	See Nos. 108, 113
112	Tilbury Man	Pearson & Bell	157·5 (F_o)	—	—	—	—	Possibly female
113	Aino	Koganei & Pearson	156·7	147·1	—	—	1·065	See Nos. 108, 111
114	Juags of Oriva	Short	—	—	156·0	—	—	—
115	Laplanders	Hepburn & Rodriguez	155·2 (F_o)	142·9 (F_o)	—	—	1·086	See No. 122
116	Negritos	Rodriguez	153·3 (F_o)	144·4 (F_o)	—	—	1·062	—
117	Veddahs	Bailey	—	—	153·0	—	—	See No. 73
118	Ostiahs	Topinard	—	—	153·0	—	—	—
119	Siamese	Topinard	—	—	152·5	—	—	See No. 107
120	*Homo mousteriensis* (*Hauseri*)	Pearson	152·4 (F_o)	—	—	—	—	From cast. See No. 82
121	Andamans (I)	Hepburn	152·3 (F_o)	143·9 (F_o)	—	—	1·058	See Nos. 123, 124
122	Laplanders	Montegazza	—	—	152·3	145·0	1·050	See No. 115
123	Andamans (II)	Man	—	—	149·2	140·3	1·063	See Nos. 121, 124
124	Andamans (III)	Pearson	147·6	144·3	—	—	1·023	See Nos. 121, 123
125	Bushmen I	Fritsch	—	—	144·4	140·4	1·028	See No. 126
126	Bushmen II	Pearson	146·0	142·0	—	—	1·028	See No. 125
127	Aigtas of Luzon	Marche & Montano	—	—	144·1	138·4	1·041	—
128	Neolithic Swiss Dwarfs	Kollmann & Pearson	148·0 (?)	141·0 (?)	—	—	1·050 (?)	See No. 105 *bis*
129	35 Bavarian Super-dwarfs	Ranke	—	—	133·9	—	—	—
130	Akkas	Pearson	120·0	124·0	—	—	·968 (!)	—
131	4 Dwarfs (< 125)	Pearson	106·6	—	—	—	—	—

II. *Obliquity of the Femur.*

We have already indicated reasons for discarding the pseudo-obliquity of Dr Warren (p. 31) and an examination of any of our tables (as that for Primogenial man and his comparatives in the following chapter) suffices to emphasise the great divergence between the real and the pseudo-obliquity. If we consider the true obliquity only we find that it has been tabled for a fairly wide range of races, but that very few conclusions have so far been deduced from its values. Our own view is that the accuracy of its determination by the mechanically badly designed osteometer of Broca (which has been customarily used) is not very great, and that until there is an international convention as to what is to be considered the "axis of the shaft" increased accuracy can hardly be expected (pp. 20 ftn. and 30). Thus any inferences to be drawn from the following table must be from such large differences that the wide variation due to errors of measurement and to personal equation in measurement must be of a secondary character[1].

The general results of this table appear to confirm our conclusions based on English data, namely that the female exceeds the male in the obliquity of the femur, and the left member exceeds the right. These results are especially noteworthy in the relatively long series of Portuguese femora provided recently by Tamagnini and Vieira de Campos. It is also confirmed for sexual difference by Schwerz in his results for the Swiss Alemanns.

That three degrees should cover practically the whole range of racial data—excluding Australians, anthropoids and primogenial man—shows how little racial differentiation can be based on this character. It has probably been of such importance as to be most stringently selected, and it is clear that only very long series are of any value for racial purposes.

The low value of the obliquity in primogenial man is one of the few instances in which he is clearly closer to the apes than more recent man. In this respect the Trinil femur is not apelike and stands far closer to modern man than to the apes.

III. *Torsion of the Femur.*

We have already referred at considerable length to the various methods which have been used to determine the Torsion of the femur, and seen how open to objection many of them are (see pp. 23—30). This variety of method supplemented by a very large factor of personal equation renders all interracial comparisons of Torsion subject to suspicion, and no marked emphasis must be laid on racial differences, not deter-

[1] A good illustration of the danger of relying on small series may be found in the data for Fuegians. Hultkrantz's data for eight femora give mean obliquity 10°·6 which would bring them second on our list of existing races. Martin's data for five femora give a mean of 8°, which places them at the bottom of our list. The mean of the 13 bones is 9°·6 or exactly at the mid-point of the list! Such results as these ought to warn the anthropologist of the dangers which arise from arguments based on small numbers.

Table IV. *Obliquity of Femur.*

Race	♂ R.	♂ L.	♂ R.+L.	♀ R.	♀ L.	♀ R.+L.	♂ + ♀	Remarks
Gorilla	—	—	2°·9 (4)	—	—	0°·4 (3)	1°·8 (7)	We are unaware of any full series of obliquity determinations in the apes. But from the examination of other specimens we are fairly certain that the obliquity is on the average small
Chimpanzee	—	—	—	—	—	—	0°·1 (2)	
Orang-utan	—	—	—	—	—	5°·2	4°·8 (5)	
Gibbon	—	—	—	—	—	—	5°·3 (3)	
Dryopithecus rhenanus	—	—	—	—	—	—	4°·0 (1)	
Pithecanthropus erectus	—	—	—	—	—	—	12°·0 (1)	Determined from photograph only
Neanderthal	—	—	—	—	—	—	5°·5 (1)	From cast
Spy	—	—	—	—	—	—	7°·0 (1)	From cast
Man from La Chapelle-aux-Saints	—	—	—	—	—	—	3°·0 (1)	From photographs
Homo mousteriensis (*Hauseri*)	—	—	—	—	—	—	1°·0 (1)	From cast
Homo aurignacensis (*Hauseri*)	—	—	—	—	—	—	7°·9 (1)	From photographs
Galley Hill	—	—	—	—	—	—	8°·5 (1)	From cast
Australian Natives	—	—	15°·2 (2)	—	—	12°·8 (2)	14°·0 (4)	Pearson
Modern Swiss	—	—	—	—	—	—	11°·0 (30)	Schwerz (sex unknown): see Bibl. No. 107
Swabians from Row Graves	10°·4 (12)	10°·7 (13)	10°·6 (25)	9°·3 (6)	11°·5 (5)	10°·3 (11)	10°·5 (36)	Lehmann-Nitsche: Bibl. No. 69
17th century Londoners	8°·7 (218)	11°·6 (233)	10°·2 (451)	9°·4 (166)	11°·8 (175)	10°·6 (341)	10°·4 (792)	Present Memoir
Bajuvars from Row Graves	—	—	—	—	—	—	10°·3 (10)	Lehmann-Nitsche: Bibl. No. 69
Neolithic French (Châlons-sur-M.)	—	—	10°·2 (22)	—	—	10°·5 (9)	10°·3 (31)	Manouvrier: Bibl. No. 71 *bis*
Indians of Paltacalo (Prehistoric Columbians)	9°·8 (30)	9°·9 (30)	9°·8 (60)	9°·5 (17)	10°·7 (17)	10°·1 (34)	10°·0 (94)	Antony and Rivet: Bibl. No. 97, pp. 381 and 383
Modern Bavarians	10°·3 (120)	9°·3 (105)	9°·8 (225)	(♂ + ♀)	—	—	9°·8 (225)	Bumüller: Bibl. No. 81, S. 70
Rothwell English	—	—	9°·4 (168)	—	—	10°·5 (99)	9°·8 (267)	Parsons: Bibl. No. 111
Swiss Alemanns	—	—	9°·4 (c. 164)	—	—	10°·0 (c. 164)	9°·7 (c. 328)	Schwerz: Bibl. No. 103
Modern Swiss	—	—	—	—	—	—	9°·7 (23)	Schwerz: Bibl. No. 103
Neolithic Swiss Dwarfs	—	—	—	—	—	—	9°·7 (3)	Schwerz: Bibl. No. 103
Portuguese	8°·6 (72)	9°·6 (62)	9°·1 (134)	9°·8 (63)	10°·5 (63)	10°·1 (126)	9°·6 (260)	Tamagnini and Vieira de Campos: Bibl. No. 118, p. 49
Fuegians	—	—	—	—	—	—	9°·6 (13)	Martin: Bibl. No. 63. Hultkrantz: Bibl. No. 85
Neolithic Swiss (Chamblands)	—	—	9°·7 (16)	—	—	9°·3 (10)	9°·5 (26)	Schenk: Bibl. No. 91 *bis*
Maori	—	—	—	—	—	—	9°·2 (5)	Mollison: Bibl. No. 100
Modern Viennese	—	—	—	—	—	—	9°·0 (100)	Mikulicz: Bibl. No. 22
Anau (Ancient Persians)	—	—	—	—	—	—	8°·0 (2)	Mollison: Bibl. No. 99

mined by the same process, and by the same observer[1]. On p. 30 of the present memoir we have pointed out how the main factor in torsion of the human femur is that of the shaft, the so-called torsion of the femur being this torsion of the shaft reduced by the retorsion of the head and neck. On pp. 136—140 we have touched upon the relation of torsion and retorsion to the upright position in man and woman. From the standpoint of uprightness the following figures seem suggestive:

Mean Values.

	Apes	Primogenial Man	Modern Man
Torsion of Shaft ...	8°·2	23°·3	25°·6
Retorsion	8°·7	13°·2	10°·3

Our figures are based on small numbers, so that there is little emphasis to be placed on the apparent divergence between the retorsion in primogenial and modern man. On the other hand the torsion of the shaft in man has nearly three times the value it has for the ape, while the *average* retorsion for the ape is greater than the torsion. This is not true for the gorilla, but it is markedly true for the orang-utan and occasionally for the chimpanzee. The gibbons we have measured show a torsion of the neck and head in the same sense as that of the shaft, but this is slight and, if the rule, needs fuller confirmation. Is the gorilla more upright than the chimpanzee and the chimpanzee than the orang-utan—is the order of uprightness the order of femoral torsion? Apart from difference of method and personal equation the torsional are the most variable characters of the femur, their coefficients are twice as great as those of any other characters, and in the case of most other characters 6 to 10 times as great[2]. Torsion of this bone is therefore a fluent character either subject

[1] The following measurements will serve to emphasise these points:

	Spy (R.)	Neanderthal (L.)
Klaatsch	12°·0	9°·5
Rivet	20°·0	13°·0
Rodriguez	13°·5	—
Present Memoir ...	6°·0	16°·0

The present writers were working on the casts, but this was probably the case with Rivet and Bello y Rodriguez also. The difference between Rivet and Rodriguez is striking as they probably both used the French method. Our method is very different. What method was used by Klaatsch we cannot say. We regret, however, to have to state that we have little confidence in his accuracy of measurement.

[2] See our Table III, p. 164. As far as we know Tamagnini and de Campos (Bibl. 118, p. 53) are the only authors besides ourselves who have calculated the variabilities of the femur. We have:

Coefficients of Variation for Torsion.

	♂	♀
17th century Londoners ...	R. 75·69 ± 3·75 L. 62·41 ± 2·74	R. 71·38 ± 3·94 L. 54·35 ± 2·57
Rothwell English	63·83 ± 3·18	54·18 ± 3·26
Modern Portuguese	66·05 ± 3·72	87·33 ± 5·90
Prehistoric Indians of Paltacalo ...	39·66 ± 2·75	50·18 ± 4·76

The values indicate a lesser variation in the uncivilised race.

to easy moulding by environment and habit, or not yet fixed by long ages of selection. From this standpoint it is of interest to note that bowing, which is 50 per cent. greater in primogenial than in modern man, has a variation only second to that of torsion (see Table IV, p. 165 and the Table of the Measurements of the Femora of Primogenial Man in Chapter X).

In the following table we place together all the torsional results we have been able to collect, again warning the reader of the heterogeneity of method which has been used in their determination[1]. For example the two groups of modern French and the two groups of Negroes measured by different authorities are unpleasantly wide apart. The prehistoric and primitive races, the modern European races, the Asiatics or the Americans do not give groups whose members fall markedly together. If we term above 24° very high torsion, 24° to 18° high torsion, 18° to 12° moderate torsion, 12° to 6° low torsion and below 6° very low torsion; then the apes are found in very low and low torsional ranges; primogenial man on the border of very low and low torsion; modern Europeans and most of their progenitors in moderate torsion; Guanches, Eskimos, Fuegians, Negroes, Negritos and Melanesians in the high torsional range; while the Polynesians are associated with Cromagnon, Maori and certain neolithic femora in the very high torsion group. We cannot, however, assert that the more primitive the race the higher the torsion, for certain primitive races like the Lapps and Veddahs appear to have extremely low torsion, in value more nearly that of the apes. Thus although the table does seem to indicate that torsion has some racial weight, there is no obvious evolutionary torsional classification and we might even anticipate local habit as enforced by environment having considerable influence on this femoral character. It would be of interest to have some measure of upright bearing applied to primitive races in order to test whether this has any relation to torsion.

Authoritative determinations of torsion of shaft and of retorsion in the apes, in primogenial man and in primitive man are very desirable. Methods of measurement badly need standardising, and it is far from adequate to define torsion as the angle between a certain "condylar axis" and the projection on the standard horizontal plane of the "axis of the neck," if these axes themselves are not more exactly defined.

[1] The majority of the authors dealt with do not state whether they have met with *negative* torsions, and if so how they have treated them. We note that Mikulicz (Bibl. 22, S. 376) is an exception to the rule. From his data for 120 (probably ♂) Viennese femora we find the angle of torsion ignoring sign 12°·95 and regarding sign 11°·57, a much greater difference than we have obtained for 17th century Londoners: see Tables IV and V, Chapter IV.

TABLE V. *Torsional Angles of the Femur.*

Race	♂ R.	♂ L.	♂ R.+L.	♀ R.	♀ L.	♀ R.+L.	♂ + ♀	Remarks
Gorilla	—	—	—	—	—	—	6°·3 (54)	Present authors, Hepburn, Rodriguez, Antony and Rivet
Chimpanzee	—	—	—	—	—	—	4°·7 (31)	,, ,, ,, ,,
Orang-utan	—	—	—	—	—	—	−4°·4 (6)	,, ,, ,, ,,
Gibbon	—	—	—	—	—	—	8°·3 (28)	,, ,, ,, ,,
Dryopithecus rhenanus	—	—	—	—	—	—	13°·5 (1)	Present authors, from cast
Pithecanthropus erectus	—	—	—	—	—	—	15°·0 (1)	Dubois, Bibl. No. 67 *bis*, S. 23
Neanderthal	—	—	—	—	—	—	6°·0 (1)	Present authors, from cast
Spy	—	—	—	—	—	—	16°·0 (1)	,, ,, ,,
Homo mousteriensis (*Hauseri*) ...	—	—	—	—	—	—	8°·5 (1)	,, ,, ,,
Man of La Ferassie II	—	—	—	—	—	—	18°·0	Rivet in Boule: see Bibl. No. 106 *bis*
Maori	—	—	—	—	—	—	39°·7 (4)	Mollison, Bibl. No. 100
"Cromagnon"	—	—	—	—	—	—	35°·0 (13)	Rodriguez speaks of 13, probably bones which are called of that type
Neolithic Man (Châlons-sur-Marne)	—	—	29°·0 (23)	—	—	27°·3 (10)	28°·6 (38)	Manouvrier, Bibl. No. 71 *bis*, p. 162
Ancient Persians (Anau) ...	—	—	—	—	—	—	27°·0 (2)	Mollison, Bibl. No. 99
Polynesians	—	—	—	—	—	—	27°·2 (18)	Rodriguez, Bibl. No. 101
Prehistoric (Naqada) Egyptians	—	—	21°·7 (33)	—	—	26°·1 (80)	24°·8 (113)	Warren, Bibl. No. 77
Negritos	—	—	—	—	—	—	23°·0 (42)	Rodriguez, Bibl. No. 101
Californian Indians	—	—	—	—	—	—	23°·1 (122)	,, Bibl. No. 101
Ancient Egyptians	—	—	—	—	—	—	22°·8 (22)	,, Bibl. No. 101
Melanesians	—	—	—	—	—	—	22°·8 (80)	,, Bibl. No. 101
Patagonians	—	—	—	—	—	—	22°·0 (101)	,, Bibl. No. 101
Indonesians	—	—	—	—	—	—	21°·0 (14)	,, Bibl. No. 101
Negroes I (locus?)	—	—	—	—	—	—	20°·7 (13)	Manouvrier, Bibl. No. 26
Fuegians	—	—	—	—	—	—	19°·8 (27)	Hultkrantz, Martin, Rodriguez
Eskimos	—	—	—	—	—	—	19°·2 (16)	Rodriguez, Bibl. No. 101
Indians of Paltacalo	—	—	19°·1 (62)	—	—	19°·2 (38)	19°·1 (100)	Antony and Rivet, Bibl. No. 98 *bis*
Berbers and Guanches	—	—	—	—	—	—	18°·5 (94)	Rodriguez, Bibl. No. 101
Neolithic Man (France)	—	—	—	—	—	—	18°·5 (240)	,, Bibl. No. 101

TABLE V. *Torsional Angles of the Femur* (continued).

Race	♂ R.	♂ L.	♂ R.+L.	♀ R.	♀ L.	♀ R.+L.	♂ + ♀	Remarks
Central American Indians (Ancient) ...	—	—	—	—	—	—	18°·24 (242)	Rodriguez's Data (pooled)
Malays	—	—	—	—	—	—	17°· 4 (118)	Rodriguez, Bibl. No. 101
Negroes II	—	—	—	—	—	—	17°· 4 (97)	,, Bibl. No. 101
Modern French	—	—	—	—	—	—	17°· 2 (79)	Manouvrier, Bibl. No. 26
Ancient Phoenicians and Carthaginians	—	—	—	—	—	—	16°· 8 (16)	Rodriguez, Bibl. No. 101
Turks	—	—	—	—	—	—	16°· 3 (18)	,, Bibl. No. 101
Bavarians	—	—	—	—	—	—	16°· 4 (152)	Bumüller, Bibl. No. 81
Ainos	—	—	—	—	—	—	15°· 7 (8)	Rodriguez, Bibl. No 101
Hindoos	—	—	—	—	—	—	15°· 7 (18)	,, Bibl. No. 101
Men of Bronze Age	—	—	—	—	—	—	15°· 5 (46)	,, Bibl. No. 101
Canary Femora (? Modern) ...	—	—	—	—	—	—	15°· 3 (287)	,, Bibl. No. 101
Ancient Peruvians	—	—	—	—	—	—	15°· 2 (75)	,, Bibl. No. 101
Indo-Chinese	—	—	—	—	—	—	15°· 0 (16)	,, Bibl. No. 101
Rothwell English	—	—	13°·27 (166)	—	—	17°·22 (100)	14°·76 (266)	Parsons, Bibl. No. 111
17th century Londoners ...	11°·63 (199)	14°·71 (210)	13°·21 (409)	14°·24 (151)	17°·90 (162)	16°·13 (313)	14°·48 (722)	Present Memoir
Modern French	—	—	—	—	—	—	14°· 4 (69)	Rodriguez, Bibl. No. 101
Merovingians	—	—	—	—	—	—	14°· 0 (140)	,, Bibl. No. 101
Ancient Slavs	—	—	—	—	—	—	13°· 8 (43)	,, Bibl. No. 101
Mediaeval French	—	—	—	—	—	—	13°· 6 (183)	,, Bibl. No. 101
Swiss Alemanns	—	—	12°·1 (c. 82)	—	—	15°·0 (c. 82)	13°· 5 (164)	Schwerz, Bibl. No. 107
Chinese	—	—	—	—	—	—	13°· 4 (6)	Rodriguez, Bibl. No. 101
Modern Germans	—	—	—	—	—	—	13°· 4 (18)	,, Bibl. No. 101
Neolithic Swiss Dwarfs	—	—	—	—	—	—	12°· 7 (3)	Schwerz, Bibl. No. 103
Gauls and Romano-Gauls ...	—	—	—	—	—	—	12°· 8 (78)	Rodriguez, Bibl. No. 101
Modern Swiss	—	—	—	—	—	—	12°· 7 (14)	Schwerz, Bibl. No. 107
Basques	—	—	—	—	—	—	12°· 3 (35)	Rodriguez, Bibl. No. 101
Recent Swiss	—	—	—	—	—	—	12°· 2 (14)	Schwerz, Bibl. No. 103
Portuguese	12°·19 (72)	11°·63 (62)	11°·93 (134)	11°·95 (63)	11°·57 (63)	11°·76 (126)	11°·85 (260)	Tamagnini and de Campos, Bibl. No. 118
Modern Viennese	—	—	—	—	—	—	11°·87 (120)	Mikulicz, Bibl. No. 22
Japanese	—	—	—	—	—	—	11°· 5 (49)	Rodriguez, Bibl. No. 101
Franks and Burgundians ...	—	—	—	—	—	—	11°· 2 (30)	,, Bibl. No. 101
Bajuvars, Swabians and Alemanns from Row Graves	—	—	8°·6 (23)	—	—	14°·9 (5)	9°· 7 (28)	Lehmann-Nitsche, Bibl. No. 69
Lapps	—	—	—	—	—	—	8°· 6 (6)	Rodriguez, Bibl. No. 101
Veddahs	—	—	—	—	—	—	0°· 2 (2)	,, Bibl. No. 101

IV. *Pithecoid Index.*

It is a well recognised feature of the simian femur as compared with that of man, that when the femur is adjusted to the standard horizontal and vertical planes the great trochanter stands almost at the same level as or even above the head. This rule is not absolutely universal; even in the anthropoids the orang is an exception, and among the monkeys Ateles and a few others are also anomalous. But it is so nearly the universal rule that it is desirable to measure the characteristic numerically. A suitable index is easily found. The height of the trochanter above the standard horizontal plane is the oblique trochanteric length, and the corresponding height of the top of the head is the oblique length. The ratio of these two lengths will suffice to mark the pithecoid character of the femur. Accordingly we term the expression 100 × trochanteric oblique length/oblique length the *Pithecoid Index*. In the following table such values of the pithecoid index as we have been able to ascertain are given for the apes and for various races of man.

The results of this table are of very great interest. The fundamental point is the exceedingly small range of variation in Recent Man. If we allow for the very small samples and the personal equation of sexing and measurement there is small doubt that 95·25, our result for the 17th century London population, will stand quite adequately as representing the pithecoid index in Recent Man. There is some evidence, as in a number of tables for other characters, that modern civilised man cuts into the middle of the range of values for prehistoric man and modern uncivilised races. There is again some evidence that neolithic man had a more simian femur than modern man, and than the primitive races of Australasia[1].

Turning now to Primogenial Man, we note that *Pithecanthropus erectus* is not in the least pithecoid in this character; its index is essentially that of modern man and not that of the gibbon. Taken as a whole Primogenial Man gives a pithecoid index of 96·9 as against the 95·2 of Recent Man. He was thus somewhat nearer the anthropoids, which give a mean of 97·5, or, if we include the gibbon, of 98·0. But the comparison is somewhat fallacious, because for this character the orang is less apelike than Recent Man and *a fortiori* than Primogenial Man. We see that Primogenial Man was in this respect almost exactly midway between the chimpanzee and the orang. The gorilla maintains the essentially pithecoid value of 100·0, and shows this apelike feature with all the Old World lesser apes. The New World monkeys have a somewhat less pithecoid index than the Old World, as we might perhaps anticipate. Thus we have:

Lemuroids 100·3 < Old World Monkeys 101·7,
New World Monkeys 98·8.

[1] It is a grave misfortune that Prochownick has measured neither the trochanteric oblique length or the diameters of the shaft of his Australian skeletons, nor have we been able to discover any other material for the Australian femur bearing on this point. It would have been very suggestive as a means of determining whether the Australian femur is not further from the Neanderthal type (*i.e.* more like the Moriori femur as we suspect) than European neolithic man is. Since writing the above the suspicion expressed has been strengthened by four Australian femora which have come into the possession of one of the present writers.

TABLE VI. *Pithecoid Index.*

	Race	Index Value ♂	Index Value ♀	Source of Data
Lemuroidea	Tarsiidae	99·6 (2)		Authors
	Lorisinae	98·4 (6)		,,
	Galaginae	99·9 (6)		,,
	Lemurinae	102·0 (18)		,,
	Indrisinae	101·9 (8)		,,
	Chiromyrdae	99·3 (2)		,,
Cebidae	Hapalinae	100·1 (16)		,,
	Nyctipithecinae	99·2 (8)		,,
	Brachyurus	99·4 (2)		,,
	Pithecia	98·1 (2)		,,
	Mycetes	98·1 (2)		,,
	Cebus	99·5 (6)		,,
	Lagothrix	98·3 (2)		,,
	Ateles	97·6 (4)		,,
Simiadae	Cynocephalus	102·6 (8)		,,
	Macacus	101·4 (14)		,,
	Cercocebus	101·8 (4)		,,
	Cercopithecus	101·3 (8)		,,
	Semnopithecus	101·2 (10)		,,
Simiinae	Gibbon	99·3 (2)		,,
	Dryopithecus rhenanus	99·2 (1)		Cast
	Gorilla	100·85 (4)	99·1 (3)	Authors
	Chimpanzee	100·0 (2)		,,
	Orang	92·7 (5)		,,

Race	Index Value ♂	Index Value ♀	Source of Data
Pithecanthropus erectus	95·6 (1)		Photographs
PRIMOGENIAL MAN:			
Neanderthal Type	96·7 (6)		Various
Cromagnon Type	97·1 (5)		Various
Galley Hill	?		—
Grimaldi Type	97·1 (2)		Verneau
Homo aurignacensis (*Hauseri*)	96·2 (1)		Photographs
RECENT MAN:			
Neolithic Swiss Dwarfs	96·3 (4)		Schwerz
Bajuvars from Row Graves	96·0 (16)	95·6 (7)	Lehmann-Nitsche
Fuegians (I)	95·7 (5)		Martin
Neolithic French	95·7 (11)	94·9 (4)	Manouvrier & Antony
17th century Londoners	95·3 (367)	95·2 (285)	Present Memoir
Ancient Columbian Indians	95·1 (50)	95·5 (34)	Antony & Rivet
Ancient Persians from Anau	94·9 (2)	—	Mollison
Modern Swiss	94·7 (21)		Schwerz
Swabians and Alemanns from Row Graves	93·8 (15)	97·8 (6)	Lehmann-Nitsche
Fuegians (II)	94·6 (8)		Hultkrantz
Maori (I)	94·5 (6)		Mollison
Maori (II)	94·3 (17)	93·9 (7)	Scott
Moriori	93·1 (6)	94·3 (3)	Scott
Australian Natives	93·9 (2)	92·3 (2)	Pearson

In this, as in some other respects, the New World monkeys seem nearer to man than the Old World monkeys, and the femur of Ateles is in certain respects more human than that of the gibbon. We shall return to the general problem of the interrelation of the femora of ape and man in Chapter X, but meanwhile we have in this section endeavoured to emphasise the importance of determining in all cases the oblique trochanteric length on which the pithecoid index depends. Our table indicates that for this character the step from Primogenial Man to an intermediate of the chimpanzee and orang would not be greater than the step from Primogenial to Recent Man. The low value of the index in the case of the orang at least indicates that in the ancestry of the anthropoids there was an element with a marked tendency to lower the height of the great trochanter to even a greater extent than we find in man, *i.e.* the low trochanter is not a purely human feature.

V. *Index of Robusticity of the Femur.*

The comparative material is here relatively ample, but is principally due to Rodriguez, who provides no sex differentiation. Unfortunately some of the series with high robusticity, and therefore of greatest interest, are so short that we cannot lay much stress on the position they take in the racial scale. Other factors more or less vitiate individual results; thus Kuhff has discarded femora with marked torsion, and he further takes his pilastric section at the level of the upper nutritive foramen, a very variable position. On the other hand, Parsons has taken an individual line; he adopts no pilastric section, but takes the maximum antero-posterior and *minimum* transverse diameter of the shaft wherever they occur, presumably if they are found at widely separated shaft sections[1]. The result appears to be manifest in the high value of the pilastric index as deduced from his material. This choice of diameters should have tended to reduce his robusticity, but this is not the case. His value for the Rothwell males would place the English mediaeval femur at the head of all the Recent Man series, and closest to that of Primogenial Man. Frankly, we do not believe in such a position for the English; it is not confirmed by our own value for the robusticity, which is in reasonable accordance with Hepburn's, and both are only slightly in excess of Rodriguez's for modern Germans and French, Tamagnini and de Campos' for modern Portuguese and Schwerz's for modern Swiss. To confirm the error in Parsons' position for the British femur we may take the data provided by Holtby for 100 femora in the anatomical school at Dublin. After reduction based upon his "least transverse diameter of the shaft," which should correspond to Parsons' transverse diameter, we find:

Index of Robusticity: Males, 12·76 (56); Females, 12·53 (44),

[1] "Evil communications corrupt good manners"—and this novel manner of taking the pilastric transverse has been followed by Tamagnini and de Campos in their, in many respects, excellent paper on the Portuguese femur (Bibl. 118, p. 239). More recently Holtby, measuring femora in the anatomy school in Dublin (Bibl. 119, p. 372), has apparently reverted to the standard method of determining the pilastric transverse, but the only value he tables for the mid-shaft diameters is, like Parsons, the "Least transverse diameter of the shaft" (*loc. cit.* pp. 380—2).

comparing well with our 17th century Londoners:

Males, 12·84 (417); Females, 12·57 (325).

The slight change in the French femur's robusticity within historical times does not suggest any change in two or three centuries such as Parsons' figures demand. We are compelled to the conclusion that there has been a marked selection of the more robust femora in his material, which renders it of small value for interracial comparisons.

There are other difficulties also in our table (p. 250) as it stands. Notably the outliers at both ends are obtained as a rule from very short series, and the grave doubt arises as to how far their position may not be due to the errors of small samples. Tarenetzsky's Aleuts belong to two skeletons only, ♂ and ♀, of which he seems in each case to have measured the R. femur only. Now the Aleuts are a fringe people of transcending interest—and they are in the scale just where we should anticipate that they should be—but it certainly would not be wise to assume that the position occupied is the true one until more data are available. Again, Koganei's Aino, Rodriguez's Japanese and Scott's Moriori are in by no means unreasonable positions. But we find that Koganei's Japanese and Rodriguez's Aino flatly contradict these results. Koganei's sample of modern Japanese is, however, much smaller than Rodriguez's, and Rodriguez's Aino sample consists only of 8 femora. We think both are probably misplaced, but until further large samples of Aino and of modern Japanese are available, we cannot definitely settle the point. The same difficulty occurs with the two series of Laplanders, and here again it seems to us more probable that Rodriguez's short series is better placed than Hepburn's still shorter one.

With all due reserve the table seems to indicate in Recent Man the following broad lines of suggestion. A short thick-boned race of men pushed out to the extremes of the earth, there to be differentiated in many respects but to retain in others similarity—this race is represented by the existing "fringe peoples" such as Fuegians, Moriori, Eskimo, Aleuts, Aino and to a less extent by Laplanders and Japanese. It may be convenient to speak of the progenitors of these "fringe peoples" as *Protoneoteric Man*—the original type of recent man. The table provides some evidence that neolithic man was somewhat nearer in femoral robusticity to this protoneoteric man than modern civilised man.

At the other end of the table we find the Asiatics and Africans with relatively slender femora. In particular the black races in all their branches, as far as the femur is concerned, are further removed than the modern white from primogenial man. As in several other cases the Europeans with their historic and prehistoric forbears occupy the centre of the table, flanked on the one side by the fringe races to which we have just referred and on the other by Australasians, Polynesians and Asiatics in the roughest of geographical orders. The ancient Egyptian appears rather as a link between Asiatic and African, than between African and European[1]. In the quality of robusticity the Egyptian, the Negro, and for the matter of that,

[1] Cf. Warren, Bibl. 77, p. 191.

the Australian, cannot be considered inferior to or more primitive than the modern European, if inferiority or primitiveness be measured by approach to the fringe races or to our Protoneoteric Man, as the nearest akin of Recent Man to Primogenial Man.

For the American Indians we have no data for the northern races, but—picked out from the Europeans and Asiatics—Fuegians 12·8 to 12·9, Patagonians 12·7, Equatorial and South American Indians 12·6, and ancient New Mexico Indians 12·0 form a fairly continuous series between the South American fringe people and the low robusticity of the eastern Asiatics and suggest connecting links.

Passing now to the question of Primogenial Man we find at once the old difficulties which attach to *Homo aurignacensis* (*Hauseri*) and to Galley Hill. The former is wholly modern in robusticity, the latter appears by its index modern, but we hold any measurement on the pilastric section of this femur of very little value for reasons elsewhere stated (see our Chapter X). On the other hand the Cromagnon type, which is based on what material we could deduce from five examples, is undoubtedly low. The explanation is, however, at once forthcoming: the Cromagnon femur has a most massive midshaft region but its extreme length greatly reduces its relative robustness. It is as we have indicated a great stride towards the femur of Recent Man, but it is on a much bigger scale. This is again illustrated in Rodriguez's value of 12·3 for the robusticity of the Cromagnon type. It appears to us to be too small a value, but we have no means of checking it as he does not give any details of the 13 individuals he claims to be of this type. We should expect to find the robusticity of the Grimaldi type much that of the Cromagnon and of our suggested Protoneoteric Man. Unfortunately we can nowhere find the magnitude of the pilastric antero-posterior diameter of Verneau's Grimaldi type, and he gives no photograph of his femora from the lateral aspect[1]. The Neanderthal type stands in robusticity where we should anticipate it—intermediate between the greater anthropoids and recent man.

Once again the Trinil femur is seen to be purely human, and while not so far distant from the Eppelsheimer femur, which has itself human robusticity, it is widely remote from recent gibbons. As in the case of the pithecoid index it is the orang among the greater anthropoids which shows the human tendency—the gorilla is far removed from the rest of the primates; but the order greater anthropoids, primogenial man, recent man holds as for the pithecoid index. The general values are:

Lemuroids 11·45 < Old World Monkeys 13·25,
New World Monkeys 11·50.

The greater anthropoids with 16·28 are closer in this character to the Old World monkeys—the gibbon being, as in the case of the pithecoid index, remote from man and from the other anthropoids. Primogenial Man—at least of the Neanderthal type—has a robusticity intermediate between the greater anthropoids and the Old World

[1] A letter to Professor Verneau asking whether it would be possible to obtain one or two further measurements of these femora either failed to reach him or received no reply.

TABLE VII. *Index of Robusticity of the Femur.*

	Race	Value of Index ♂	Value of Index ♀	Source of Data
Lemuroidea	Tarsiidae	9·9 (2)		Authors
	Lorisinae	12·1 (6)		,,
	Galaginae	12·6 (6)		,,
	Lemurinae	12·1 (18)		,,
	Indrisinae	10·2 (8)		,,
	Chiromyrdae	11·8 (2)		,,
Cebidae	Hapalinae	12·1 (16)		,,
	Nyctipithecinae	10·3 (8)		,,
	Brachyurus	9·3 (2)		,,
	Pithecia	10·3 (2)		,,
	Mycetes	12·1 (2)		,,
	Cebus	11·2 (6)		,,
	Lagothrix	14·4 (2)		,,
	Ateles	12·2 (4)		,,
Simiadae	Macacus	14·3 (14)		,,
	Cynocephalus	14·0 (8)		,,
	Cercocebus	12·3 (4)		,,
	Cercopithecus	13·7 (8)		,,
	Semnopithecus	11·9 (10)		,,
Simiinae	Gibbon	9·4 (2)		,,
	Dryopithecus rhenanus	12·3 (1)		Cast
	Gorilla	18·9 (4)	18·0 (3)	Authors
	Chimpanzee	15·5 (2)		,,
	Orang-utan	14·9 (5)		,,

Race	Value of Index ♂	Value of Index ♀	Source of Data
Pithecanthropus erectus	12·7 (1)		Photographs & Dubois
PRIMOGENIAL MAN:			
Neanderthal Type	14·3 (6)		Various
Galley Hill	12·4 (1)?		Cast
Cromagnon Type	13·0 (5)		Various
Grimaldi Type	?		—
Homo aurignacensis (*Hauseri*)	12·6 (1)		Photographs & Klaatsch
RECENT MAN:			
Andamans	11·2 (12)		Hepburn
Sandwich Islanders	11·5 (5)		,,
Hindoos I	11·6 (8)		,,
Ancient Egyptians	11·7 (22)		Rodriguez
Indo-Chinese	11·75 (16)		,,
Negroes I	11·75 (11)		Hepburn
Negroes II	11·8 (97)		Rodriguez
Melanesians	11·8 (80)		,,
Romano-British	11·8 (5)		Hepburn
Maori I	11·9 (15)		,,
Hindoos II	11·9 (18)		Rodriguez
New Mexico Indians (Saladonians)	12·0 (131)		Mathews & Workman
Polynesians	12·1 (18)		Rodriguez
Veddahs I	12·1 (2)		,,
Malays	12·1 (118)		,,
Bushmen	12·1 (1)		Hepburn
Negritos	12·1 (42)		Rodriguez
Maori II	12·2 (17)	12·2 (8)	Scott

Race	Value of Index ♂	Value of Index ♀	Source of Data
RECENT MAN (*continued*):			
Japanese I	12·2 (20)	11·5 (20)	Koganei
Veddahs II	12·2 (8)	11·9 (3)	P. and F. Sarasin
Chinese	12·2 (6)		Rodriguez
Canary Islanders	12·2 (287)		,,
Maori III	12·2 (8)		Mollison
Indonesians	12·3 (14)		Rodriguez
[Cromagnon Type	12·3 (13)		,,]
Modern Swiss	12·3 (30)		Schwerz
Swabians and Alemanns from Row Graves	12·3 (25)	11·7 (11)	Lehmann-Nitsche
Modern French	12·3 (69)		Rodriguez
Laplanders I	12·4 (4)		Hepburn
Aino I	12·4 (8)		Rodriguez
Portuguese	12·5 (132)	12·5 (126)	Tamagnini and de Campos
Mediterranean Race	12·5 (32)		Rodriguez
Australians	12·5 (14)		Hepburn
Turks	12·5 (18)		Rodriguez
Modern Germans	12·5 (18)		,,
Franks and Burgundians	12·6 (30)		,,
Equatorial and South American Indians	12·6 (452)		,,
Ancient Etruscans	12·6 (33)		Sergi
Neolithic Europeans	12·6 (240)		Rodriguez
Modern British	12·6 (39)	—	Hepburn
Basques	12·6 (35)		Rodriguez
Berbers and Guanches	12·6 (94)		,,
Patagonians	12·7 (101)		Rodriguez
Sicilian Neolithics	12·7 (9)		Ruggieri
Men of Bronze Age	12·7 (46)		Rodriguez
Neolithic Swiss Dwarfs	12·7 (4)		Schwerz
Bajuvars from Row Graves	12·7 (26)	12·8 (9)	Lehmann-Nitsche
*French Neolithics I	12·8 (8)		Kuhff
Modern Irish (?)	12·8 (56)	12·5 (44)	Holtby
17th century Londoners	12·8 (417)	12·6 (325)	Present Memoir
Merovingians	12·8 (40)		Rodriguez
Gauls and Romano-Gauls	12·8 (78)		,,
Fuegians I	12·8 (12)		,,
Eskimo I	12·9 (13)		,,
Fuegians II	12·9 (10)		Hultkrantz
Phoenicians and Carthaginians	13·0 (16)		Rodriguez
Moriori	13·0 (6)	12·4 (3)	Scott
Ancient Slavs	13·1 (43)		Rodriguez
Japanese II	13·1 (92)		,,
Laplanders II	13·1 (6)		,,
Swiss Neolithics	13·2 (20)	12·2 (17)	Schenk
Eskimo II	13·2 (4)		Hepburn
*French Neolithics II	13·3 (19)		Kuhff
Aino II	13·4 (46)	13·0 (26)	Koganei
Rothwell English	13·5 (184)	12·9 (106)	Parsons
*Aleuts	13·7 (2)		Tarenetzsky
Dolmens of Lozère	13·7 (5)		Kuhff

* For reasons previously given these are of doubtful value. Neolithic Series II was from Baye, and Neolithic Series I from the Caverne de l'Homme Mort.

monkeys, and he cannot be differentiated from the apes by this femoral character. Indeed the step from orang to Neanderthal Man is less than from the Eskimo to the Chinaman. Nor can we assert that Eskimo and Chinese femora differ as *wholes* less from each other than orang and Neanderthal femora, until we have a scientific measure for estimating the differences between two individuals judged by a multiplicity of characters. It is not hard to provide theoretically such a measure, but at present data for the correlations of the characters which it involves are too sparse to render it of value.

B. . Diaphysial Characters.

VI. *Platymeric, Pilastric and Popliteal Indices.*

We devote this section of our memoir to the consideration of the cross-sections of the shaft as represented by the above indices. It has been very customary to consider these indices as uninfluenced by sex and side; thus the bulk of comparative data deals with the indices regardless of such factors. We have shown that there is in these cases considerable differentiation with sex and side, but in order to form a table for comparative racial purposes we have been compelled to pool all bones in our own series.

The pilastric index was introduced by Broca and was originally termed the *indice femoral*. A table of pilastric indices due to Broca has been published by Topinard[1]. According to Broca the quadrupeds have indices from 116 to 104, the lower races of monkeys 105 to 96, the anthropoids 95 to 77, and man 122 to 105. Thus a "scission" is made in the order of the primates, for the quadrupedal apes separate man from the anthropoids. Manouvrier endeavours to account for this[2] by remarking that man is exclusively a walker, the anthropoids are almost exclusively climbers, while the quadrupedal apes are both climbers and walkers. With one exception the average pilastric index of any human group is over 100, and the average of any anthropoid group under 100. Yet in individual cases the pilastric index in man may fall as low as 85, and we have ourselves a gorilla femur in which the pilastric index rises to 94·4 and a gibbon femur in which it rises to 105·3. In other words, the ranges of this index in man and the anthropoidal apes to a considerable extent cover each other, and the individual pilastric index—notwithstanding the "scission" in the order of the primates—is no useful criterion of what is human and what apelike.

The platymeric and popliteal indices were introduced by Manouvrier, the former to measure the flattening in the subtrochanteric region so peculiar to the Maori and Moriori femora. But platymery has not shown itself a marked character of the lower types of man, or, if it be, Australians and Negroes must be looked upon as exceptions, for they are scarcely more platymeric than modern Bavarian or Londoner. Nor is

[1] *L'Anthropologie*, Edn. 1885, p. 1018. An extension of Broca's Table is given on our p. 270.

[2] Bibl. 57, p. 144.

TABLE VIII. *Chief Shaft Section Indices in various Races.*

Race (with oblique length of male femur)	Platymeric Index		Pilastric Index		Popliteal Index		Authorities (data drawn from)
	No.	Magnitude	No.	Magnitude	No.	Magnitude	
Lemuroidea	42	92·6	42	100·6	42	81·4	Present Authors
Cebidae	42	89·7	42	95·6	42	72·1	
Simiadae	44	96·5	44	100·8	44	79·2	
Gorilla	71	81·6	75	76·2	8	57·4	Rodriguez, Bumüller, Hepburn, Antony, Rivet and Present Authors
Orang-utan	12	72·2	17	79·4	8	63·0	
Chimpanzee	48	82·7	50	84·7	7	72·9	
Gibbon	41	86·3	45	97·1	7	81·4	
Dryopithecus rhenanus (Eppelsheim) (287·0)	1	91·5 —	1	98·3 100·0	1	63·5 65·4	Present Authors Bumüller
Pithecanthropus erectus (452·0)	1	93·9??	1	109·1?	1	88·9?	See footnote *
Neanderthal (419·6)	5	77·6	5	108·1	5	79·4	Various
Spy (426·5)	2	77·2	2	102·0	1	86·1—	Klaatsch
Grimaldi (434·0)	2	82·8	—	—	2	80·0	Verneau & Authors
Cromagnon (519)	5	73·0	5	125·1	5	81·0	Various sources
Galley Hill (423·0)	1	66·7	1	99·2	1	69·2	Pearson & Bell
Homo mousteriensis (*Hauseri*)	1	77·7	1	104·6	1	69·9	Authors from cast
Homo aurignacensis (*Hauseri*)	2	86·4	2	114·3	—	—	Klaatsch
Negroes (various) (455·4)	106	83·0	106	108·5	9	81·8	Rodriguez, Hepburn and others
Melanesians (444·7)	80	79·3	80	114·7	—	—	Rodriguez
Negritos (380·4)	42	81·8	42	116·0	—	—	Rodriguez
Hindoos (probably low caste) (415·8)	24	79·0	10	112·6	6	82·8	Rodriguez & Hepburn
Veddahs (442·5)	2	88·5	13	118·8	—	—	Sarasins & Rodriguez
Andamans (375·1)	12	78·0	12	113·5	12	77·3	Hepburn
Malays (421·8)	118	76·7	118	114·8	—	—	Rodriguez
Polynesians (448·5)	18	68·3	18	110·0	—	—	Rodriguez
Australians (467·3)	14	82·2	14	122·2	14	85·3	Hepburn
Maori (435·6)	36	65·5	38	114·3	15	77·5	Scott, Mollison and Hepburn
Moriori (440·2)	9	63·4	9	112·6	—	—	Scott
Prehistoric Mussel Heaps of Japan (—)	7	[72·7]†	13	110·4	—	—	Koganei
Aino (405·7)	81	[72·2]†	80	103·2	—	—	Koganei & Rodriguez
Japanese (406·8)	132	[77·0]	132	102·4	—	—	Rodriguez & Koganei

* Manouvrier (Bibl. 68, p. 361) gives 97·0, Hepburn (Bibl. 71, p. 2) 96·9 for the popliteal index; the former value is the more correct, if we can trust the magnitudes (33 and 32) cited by both for the popliteal transverse and antero-posterior diameters. But how did Manouvrier ascertain these? Bumüller (Bibl. 81, p. 112, Tabelle II) gives 96·97, without stating its source, but follows it with 78·4 in brackets, an indication that this latter value was obtained from Dubois' plate. We obtained a doubtful value 88·9 from the plate. Our value 93·9 for the platymeric index is also drawn from the plate, but it is wholly doubtful owing to the exostosis in the subtrochanteric region. The value of the pilastric index is that cited by Bumüller and Klaatsch. We do not know its origin, but it agrees reasonably with our 108·7 from the reproduction.

† Values obtained by individual methods and not accurately comparable with other values in this table.

TABLE VIII. *Chief Shaft Section Indices in various Races* (continued).

Race (with oblique length of male femur)	Platymeric Index		Pilastric Index		Popliteal Index		Authorities (data drawn from)
	No.	Magnitude	No.	Magnitude	No.	Magnitude	
Fuegians (426·8)	22	70·1	22	105·1	—	—	Hultkrantz & Rodriguez
Patagonians (462·3) ...	101	74·3	101	110·8	—	—	Rodriguez
South and Equatorial American Indians (415·9)	317	73·5	346	106·6	—	—	Rodriguez & Bumüller
North American Indians (427·2) ...	135	73·4	450	113·7	—	—	Mathews, Workman, Rodriguez, etc.
Eskimos (424·5)	17	80·7	17	109·8	4	77·6	Rodriguez & Hepburn
Laplanders (390·4)	10	78·7	10	107·1	4	70·9	Hepburn & Rodriguez
Canary Islanders (445·8) ...	287	74·7	101	110·2	—	—	Rodriguez
Guanches (447·6)	97	75·9	97	110·9	2	80·4	Rodriguez & Hepburn
Phoenicians and Carthaginians (437·6) ...	16	76·5	16	108·5	—	—	Rodriguez
Neolithic Europeans (444·3)	240	75·1	240	111·1	—	—	Rodriguez
Bronze Age Europeans (431·6)	46	71·5	46	103·7	—	—	Rodriguez
Ancient Slavs (441·7) ...	43	74·7	43	103·6	—	—	Rodriguez
Ancient Etruscans (459·4) ...	—	—	39	105·7	—	—	Sergi
Basques (425·7)	35	79·4	35	104·5	—	—	Rodriguez
Gauls and Romano-Gauls (460·6) ...	78	77·0	78	103·7	—	—	Rodriguez
Franks, Burgundians and Merovingians (451·2) ...	70	77·6	70	105·1	—	—	Rodriguez
Mediaeval French (448·9) ...	183	82·4	183	105·1	—	—	Rodriguez
Modern French (451·3) ...	129	82·6	129	104·8	—	—	Tramond & Rodriguez
Romano-British (447·3) ...	7	67·7	8	98·3	8	73·8	Hepburn
Mediaeval British (Rothwell) (454·5)	290	[79·3]*	291	[106·4]*	—	—	Parsons
17th century Londoners (444·9) ...	855	84·2	867	103·2	826	69·6	Pearson & Bell
"Modern British" (459·0) ...	44	84·6	44	109·4	44	[78·2]	Hepburn
Swabians and Alemanns from Row Graves (464·2)	87	79·7	94	105·3	—	—	Lehmann-Nitsche
Bajuvars from Row Graves (468·0)	30	80·2	182	103·8	—	—	Lehmann-Nitsche
Bavarians (448·2)	410	83·9	415	100·7	53	79·0	Bumüller
Modern Germans (459·4) ...	18	84·4	18	101·9	—	—	Rodriguez
Swiss Alemanns (462·7) ...	235	78·5	244	103·4	—	—	Schwerz
Modern German Swiss (447·1)	30	85·9	30	104·4	—	—	Schwerz & Martin

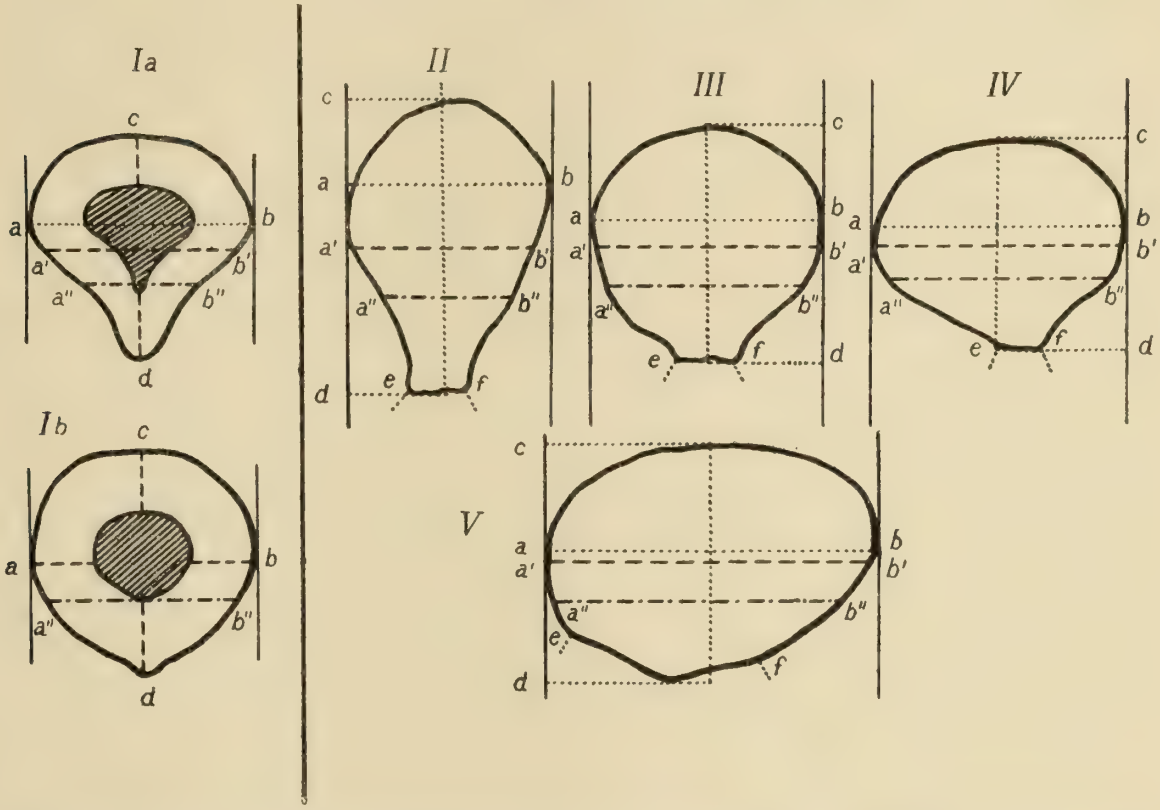
* Values obtained by individual methods and not accurately comparable with other values in this table.

platymery a marked feature of the apes—at least no genus yet investigated has it so intensely as Moriori, Maori or Fuegians.

The popliteal index was at first introduced with a view of settling whether the Trinil femur must be considered human or apelike. The result is unexpected. In the first place the types of early man appear to differ more in popliteal index from the anthropoid apes than modern man does, and, secondly, it may be doubted whether anybody except the owner of the Trinil femur knows what its popliteal index really is!

It will accordingly be recognised that the popliteal or platymeric index in the case of an individual bone is of small service as a criterion of the apelike or the human. The pilastric index is somewhat different, because although the human and ape ranges cross each other no *average* for a human race falls as low as those for the anthropoids. Yet the quadrupedal apes can show averages as high as German or English. Indeed, the tendency in modern as distinguished from primitive races of man seems to be a fall in the pilastric index. The tendency of course has not carried man back to anything like the anthropoid values, but on the whole it appears to exist. The misfortune

Pilastric Cross-section of Femur.



Ia and Ib midshaft sections showing the same pilastric index ; one with, the other without sensible pilaster. *cd* = antero-posterior, *ab* = transverse diameter, *a'b'* = mid-point breadth, *a''b''* = third-point breadth, *ef* = breadth of *linea aspera*. Outlines of Ia and Ib diagrammatic ; outlines of II Australian (148), III Shetland (100), IV modern British (85·7), V gorilla (73·0) after Hepburn. II is "pyriform," III is "rotiform" and IV and V "maliform."

of the pilastric index is that while it measures the pilaster it measures other things also, and a gibbon with a pilastric index of 100 may merely exhibit a circular cross-section and show nothing of the rounded pear-shape of a human section of like value. What is needed is a better measure of the pilaster than is provided by the pilastric index. In the accompanying diagram two midshaft sections I a and I b are roughly indicated. They have practically the same pilastric index, but the lower one is without a pilaster, while the upper is markedly pilastric. It is clear that the pilastric index is no criterion of the human or apelike characteristics of these two sections.

Now the essential difference between these is that the maximum transverse diameter *ab* is more nearly central in the non-pilastric than in the pilastric section, and the displacement of the position of the maximum transverse diameter is an essential feature of pilastry. The suggestion which naturally arises is that the pilastric transverse should be taken not as the maximum transverse diameter, wherever it occurs, but either as the mid-breadth of the section, or possibly as the posterior third-point breadth. Another *à priori* interesting character would be the distance of the maximum breadth from the mid-point of the pilastric antero-posterior diameter. We have found, however, that owing to the frequent flatness of the mesial and lateral walls of the bone this distance, and therefore any index based upon it, is not capable of very exact determination. Taking an Australian, a Shetland, a modern British and a gorilla femur given by Hepburn with pilastric indices of 148, 100, 85·7 and 73 we have measured on the drawings he gives of the pilastric sections the mid-point and third-point breadth pilastric indices, and have obtained the following results:

	Maximum Breadth Index	Mid-Point Breadth Index	Third-Point Breadth Index
Australian	148	161 (9 °/₀)	243 (64 °/₀)
Shetland	100	104 (4 °/₀)	115 (15 °/₀)
Modern British	85·7	85·7 (0 °/₀)	95 (11 °/₀)
Gorilla	73·0	73·2 (0·3 °/₀)	81·5 (11 °/₀)

The increases per cent. are given in brackets. Thus with the non- or slight-pilastered femora the increase does not amount to more than 15 per cent., but with the emphatic pilasters to 64 per cent. There is little doubt in our minds that 243, 115, 95 and 81·5 represent much better than 148, 100, 85·7 and 73 the relative importance of the pilaster in these four extreme cases.

Two further pilastric indices also claim our attention:

(i) The *Index of the Linea Aspera.* We take this to be 100 × the breadth *ef* between the lips of *linea aspera* at the pilastric section divided by the antero-posterior diameter of the section. For man this index falls in the twenties. For the anthropoids this index may rise to nearly four times its value in man, *e.g.* to over 80 in the gorilla.

(ii) The *Ellipto-pilastric Index.* Suppose a circle described on the antero-posterior diameter as diameter and let its area be C. Then let A be the area of the pilastric cross-section read with a planimeter. When there is any significant pilaster C is greater than A, that is to say when the section is elliptic with major axis sagittal; when there is absence of pilaster as in the apes the section is elliptic with major axis transverse or C is less than A. We take as ellipto-pilastric index the value $100\ C/A$. Clearly such an index discriminates accurately between cases in which, while the antero-posterior and transverse pilastric diameters are equal, there is and there is not a true pilaster.

For the marked Australian case referred to above the ellipto-pilastric index is 115·7, for the Shetland case 97·7, and for the extreme British case 91·5, which is probably almost a limit on the minimum side for man. For the gorilla section figured by Hepburn it is only 71·6.

The actual determination of the Third-Point Pilastric Index requires a drawing of the cross-section, and that of the Ellipto-pilastric Index a drawing of the cross-section and the use of the planimeter. The two indices can be easily obtained by the use of an instrument devised a number of years ago by one of us, which at the same time draws any contour of a solid body and reads off the area of that contour. The Index of the *Linea Aspera* can be determined at once by any small pair of calipers. We have referred to the matter here because we believe that some explanation is needful of the comparative failure of the pilastric index to discriminate between man and the apes and between the various races of man. It seems to us not the best index that could have been chosen as a criterion. The pilaster is a very real feature with marked variations. A good pilastric index has not to distinguish in the first place between ellipses with major axes in directions at right angles, but between pear-shaped and apple-shaped sections, and this Broca's index fails to do.

We hope later to devote a special study to the comparative value of various pilastric indices. In this memoir we content ourselves with the criticisms which arise almost unbidden from an examination of the preceding table of racial indices (p. 253). No form of anthropometry can be reasonably successful in racial differentiation if the measuremental functions do not adequately express changes in the racial character. It is the racial character which first appeals to the eye, and it is the business of the anthropometrician to be quite certain before he takes into general use any measuremental function that it really does reproduce numerically the phases of the character he desires to discriminate. It is not needful that his function should express every shade in those phases—the character may be multiplex and only some principal factor expressible by aid of the function—but it should at least describe the change of the character in its broad outlines. A measuremental function is inadequate if it can take the same value in an individual which possesses and in one which does not possess the character under discussion, and this can be the case with the so-called pilastric index.

To take this attitude with regard to badly chosen measuremental functions is not to place all statistical work in anthropometry, as Klaatsch did, in a secondary position[1]. Such work is absolutely primary and the only road to safe generalisation. When the statistical and the appreciative methods are placed side by side, the former being based on fitly chosen measuremental functions, there cannot be for a moment a doubt as to which will give the better results—that is evidenced in every case by the ultimate appeal of the appreciative anthropologists to the very statistical methods—generally imperfectly handled—which they started by endeavouring to discredit. They feel their appreciations will carry no weight unless they have statistical support. Even when we have only an imperfect measuremental function, there is no real evidence to show that more knowledge will not flow from it than from the appreciative method unaccompanied by any measurements at all. The comparative, but far from complete failure of cephalic index or pilastric index has not arisen from their being essentially bad, but

[1] See in particular *Globus*, Vol. 76, p. 355, 1899. Statistics are to be wholly subordinated to the dictates of comparative anatomy, yet the anatomist is not to hesitate in appealing to them, when they do not disprove his prejudgment.

from their only imperfectly expressing what was originally supposed to be involved in them. The progress of anthropometry will demand more and more complicated measurement functions rather than a return to those appreciative methods which were so characteristic of the earlier anthropologists and are not without their champions to-day.

An examination of Table VIII brings out a number of interesting points. Platymery in its extreme forms is not a distinguishing feature of mankind as a whole. It is peculiar to Moriori, Maori, the primitive inhabitants of Japan, the Fuegians and the Polynesians—our "fringe-races"[1]. But the orang-utan is almost as platymeric as the last of these. The Asiatics as a whole fall between the orang and gorilla or chimpanzee, while the most highly civilised races of to-day are only about as platymeric as the gibbon. It is, however, important to note that all the modern European races dealt with seem to indicate that their progenitors were more platymeric than the moderns. This appears to be true of the ancient inhabitants of Europe and the Guanche, Canary, Berber group. The whole of the original inhabitants of America had marked platymery if not so extreme as that of Moriori and Maori. If we attempt to associate platymery with any physical need of primitive races, probably the necessity for speed would occur to many and possibly find confirmation in the recognised speed of the American Indians. But it would be difficult to separate the non-agile orang from other anthropoids on this ground. Any explanation must probably be sought first in the correlation between platymery and other features of the femur—a point to which we shall return. It is clear that the "scission of the primates," if not wholly of the same character, is involved in platymery as in pilastry.

In the pilastric index it is again not the most civilised races which exhibit most pilaster, as judged by the pilastric index. It is the Asiatic and Australasian groups which are most pilastric, the American Indian group follows, and the modern Europeans show probably the lowest general pilastric index, possibly but not certainly lower than the early and prehistoric Europeans[2]. The modern Japanese are lower than the earlier inhabitants of Japan while the latter like the European neolithic group approach the Guanche-Canary and Negroid groups. If we can trust the small numbers of the Neanderthal and Spy cases, there was marked difference between them and the Cromagnon type. The modern European differs from the neolithic European almost as the Cromagnon from the Neanderthal type. While pilastric and popliteal indices give the like order for the anthropoids, at present the orang-utan stands out of place in platymery. Possibly some change may be made when a larger number of orang femora have been measured. But notwithstanding the gorilla femur is furthest and the gibbon femur nearest in the values of these indices to Neanderthal man. It is such a resemblance, however far removed, which in part has led Bumüller to speak of the

[1] A similar link between Maori, Moriori, Fuegian and Aino has been pointed out with regard to features of their crania: see *Biometrika*, Vol. xi, pp. 101 *et seq.*

[2] Probably no stress can be laid on the small Romano-British group or Hepburn's very heterogeneous series of modern British. Parsons' result which should have been useful is not comparable. Thus it is hard to determine any direction of change in the British group. The French group shows little change, but the Germans a considerable fall. Modern European races are less pilastric than neolithic European races.

Trinil femur as that of a giant gibbon! Before much stress can be laid on such slight correspondence of indices as exists those for *Pithecanthropus erectus* must be far more accurately determined than they are at present.

In the popliteal index there is a fairly continuous rise from the gorilla to early man broken, however, by the positions of *Cebidae* and *Simiadae* with regard to the anthropoids. Here, as in the pilastric index, the *Simiadae* stand between the gibbon and man. Unfortunately our popliteal indices are few and the data on which they are based very scant. But it seems probable that while some few primitive races—Maori, Lapps and Andamans—have an almost apelike value of the popliteal index, others like the Australians, Negroes and the Neanderthal type have a high one. We have not enough races of modern man measured to be dogmatic, but it would appear that, as in the case of the platymeric index, the English at least and possibly the Germans have receded to the more apelike form of the popliteal section[1]. It must be remembered that the popliteal index was originally introduced as a means of analysing at least partially the nature of the popliteal area. This it is only partially successful in doing. The ape has a low popliteal index but its popliteal area as a rule is convex. In the case of man, however, the concave femora as a rule have a low popliteal index but the convex femora have a high index. The exaggerated popliteal transverse in the apes more than compensates for the increased antero-posterior diameter due to the convexity. Thus in modern man the low popliteal index may be due to increased concavity, while the high popliteal index in the Australian may be due to convexity associated with a transverse diameter much reduced on that of the ape. Had a true measuremental function of the curvature of the popliteal surface been taken—say, subtense by chord at posterior boundary of popliteal section[2]—we should probably have found an evolutionary order: ape, Australian, modern European, instead of the popliteal index order: ape, modern European, Australian. We have thus another instance of an imperfect measuremental function arising from a non-adequate geometrical appreciation rather than from a real defect in statistical method. It is easy to demonstrate the truth of this view. We have for mean values from Hepburn's data:

No.	Race	Popliteal Transverse	Popliteal Antero-Posterior
15	Maori	37·76	28·60
14	Andaman (I)	28·92	22·21
12	Andaman (II)	37·24	28·60
14	Australian	33·57	28·64

Andaman (I) denotes actual Andaman values. Andaman (II) denotes actual values magnified so that the smaller Andaman has the same antero-posterior diameter

[1] A noteworthy position is occupied by the Galley Hill femur in regard to all three indices—it provides values which hardly smack of modernity.

[2] This index would have been positive for the apes on the average, probably about zero for the Australian and Neanderthal man and actually negative for modern man. Our own Australian femora fall into the "flat" category.

as the bigger Maori; he has now also the same transverse diameter. The Australian had the same antero-posterior diameter to start with; but we see that his popliteal transverse is much shorter. His high popliteal index is simply due to this diminution of popliteal transverse, and not to an increased antero-posterior diameter, the result of greater convexity. The popliteal index is thus only an imperfect measure which does not properly discriminate between two fundamental factors, concavity of area and ellipticity of section.

At the same time, if we allow that these shaft indices determine ellipticity rather than the extent of pilaster or of convexity in the popliteal area, it is not without interest to determine to what extent the general ellipticity of the subtrochanteric region is or is not associated with those of the midshaft and popliteal regions. This problem in a restricted sense has been a good deal discussed, but by rather inadequate methods. Attention was first drawn to it by Manouvrier, who considered whether increase in platymery was associated with a change in the pilastric index. Kroutowski in 1892[1] dealing with neolithic femora from Châlons-sur-Marne and Mareuil-les-Meaux gave the following slender data:

	No. of Femora	Platymeric Index	Pilastric Index
1st Group	4	90·4	118
2nd Group	5	77·6	105

According to this a high platymeric index is associated with a high pilastric index or accentuated platymery with an absence of pilastry. Manouvrier in the following year[2] dealt with a small collection of femora from Andresy of the Merovingian epoch and gives the following results:

	No. of Femora	Platymery	Pilastric Index
1st Group	17	None	110·3
2nd Group	18	Feeble	104·0
3rd Group	19	Accentuated	100·5

As far as these go they confirm Kroutowski. But the method and total frequency is inadequate, and the classification of platymery unsatisfactory.

Still a further table of the same character is given by Manouvrier and Antony[3] for the neolithic femora from Montigny-Esbly.

	No. of Femora	Platymeric Index	Pilastric Index
1st Group	15	80·1	120·5
2nd Group	17	79·7	111·8
3rd Group	18	76·2	105·1
4th Group	13	74·1	98·9

[1] Bibl. 54, p. 483.

[2] Bibl. 57. See also "Étude des ossements humains de l'époque mérovingienne trouvés à Andresy." *Association française. Congrès de* 1890.

[3] Bibl. 96.

Here again the method of selection to get means of groups is not clear, and considering the variation in both indices, the correlation method used is inadequate, and almost any series of results might be deduced by various processes of selecting groups. Still all these results confirm the view that both indices increase and decrease together. Some confusion, however, was introduced into this more or less accurate result by Manouvrier's use of the term "transverse platymery" for extreme cases of what we should now term stenomery. The reader who will examine our correlation tables for the platymeric and pilastric indices will not, however, find that there is anything special in the bulk of stenomeric cases; they are associated, as we should expect them to be, with the higher pilastric values, and they do not correspond to the same association as the sagittal platymery which is found with the lower pilastric values. Bumüller[1] also gives a somewhat crude correlation table:

Pilastric Index

Platymeric Index	(I) Up to 90 (exclusive)	(II) 90—100	(III) 100—110	(IV) Over 110	(V) Under 100 + Pilaster	Totals
Up to 100	0	1	22	24	1	48
99·9—85	11	15	62	33	8	129
84·9—80	12	14	30	9	8	73
Under 80	28	26	47	9	44	154
Totals	51	56	161	75	61	404

It is very difficult to do anything with this table, partly owing to the largeness of the groupings, partly because the subranges are not equal ("up to" and "over" give no proper subranges, and where is the pilastric index 100 put?), and partly because of the anomalous Group V, "under 100 with pilaster." The existence of such a group only shows the inadequacy of the pilastric index as a measure of the pilaster. To obtain a rough measure of the correlation we have divided Group V between Groups I and II, and then formed a tetrachoric table as follows:

Pilastric Index

	Up to 100	Over 100	Totals
Up to 85	132	95	227
Over 85	36	141	177
Totals	168	236	404

The tetrachoric coefficient = +·58. Thus we see that Bumüller's data confirm Manouvrier's statement that high platymeric indices are associated with high pilastry, and considering the roughness of the table and the two grave divergences between his methods and ours[2] the correlation value is not numerically so very far from those of our correlations on the following page.

[1] Bibl. 81, S. 47.

[2] Bumüller includes the gluteal ridge in his platymeric antero-posterior diameter and he avoids the place where the pilastric antero-posterior diameter is a maximum.

Bumüller while himself quantitatively reaching the same result as Manouvrier, *i.e.* increase of platymeric index (*not* be it noted of platymery) with increase of pilastric index, appears to criticise all results reached by Manouvrier in the matter[1]. Klaatsch, after referring to Manouvrier, Boncour and Bumüller, holds that a relation exists between pilastry and platymery, but that its nature has not yet been cleared up. We have no hesitation in saying that there is very considerable correlation of a positive sense between platymeric and pilastric indices. Our tables are given below, pp. 272 *et seq.*, and our correlations taken from Table II of Chapter VI, p. 194, are :

♂ R.	♂ L.	♀ R.	♀ L.
$+ \cdot 551 \pm \cdot 031$,	$+ \cdot 455 \pm \cdot 034$,	$+ \cdot 388 \pm \cdot 043$,	$+ \cdot 405 \pm 041$.

To compare with these values we may take a table prepared by Schwerz[2], wherein the permilles of each pilastric and platymeric index are given for the Alemanns of Switzerland. Unfortunately his table sums to 970 instead of 1000, and there must be an error somewhere. He speaks of using 430 femora, but if the numbers in his table be multiplied by ·43, they sum to 418 and not 430. The table given below

Platymeric Index

Pilastric Index	Up to 64	65—69	70—74	75—79	80—84	85—89	90—94	95 and over	Totals
Up to 89	4	4	2	1	1	1	—	—	13
90—94	1	5	15	6	2	1	—	—	30
95—99	1	3	1	9	7	3	2	—	26
100—104	2	9	28	42	35	21	8	1	146
105—109	2	1	12	14	19	10	7	1	66
110—114	1	3	11	10	16	13	13	4	71
115—119	—	1	5	5	7	3	9	4	34
120 and over	—	1	1	2	6	13	4	5	32
Totals	11	27	75	89	93	65	43	15	418

then results, which is the most consistent correlation table we can reconstruct out of Schwerz's data. It leads to the values :

	Mean	Standard Deviation	Correlation
Pilastric Index ...	105·74	7·10	$+ \cdot 629 \pm \cdot 020$
Platymeric Index	79·97	6·73	

This compares fairly well with the $+ \cdot 58$ for the Bavarians. If we were to take the mean value of our four coefficients directly weighting with their frequencies, it would be $+ \cdot 456$. Are we then to conclude that there is a somewhat higher relationship between the indices of the Germanic group than between those of our London group ? We cannot think this demonstrated, and for three reasons : (i) Bumüller's methods differ in important points from ours, and clearly in measuring the pilastric index Schwerz had some prejudice in favour of the decades, which might well emphasise the correlation. (ii) Both the tables we have deduced from Bumüller and

[1] Bibl. 81, S. 47—48.

[2] Bibl. 107, S. 655.

Schwerz's data are to some extent guesswork, as their material is not given in a form from which such tables can be accurately deduced, and lastly, (iii) they have combined right and left sides and both sexes.

Now our values are

	♂ R.	♂ L.	♀ R.	♀ L.
Pilastric Index Mean ...	105·81 ± ·42	105·13 ± ·38	103·85 ± ·46	99·48 ± ·46
„ „ S. D. ...	9·532 ± ·295	9·262 ± ·279	9·166 ± ·321	9·423 ± ·322
Platymeric Index Mean	85·33 ± ·39	85·11 ± ·40	84·08 ± ·48	81·75 ± ·40
„ „ S. D. ...	8·765 ± ·272	9·347 ± ·284	9·606 ± ·342	8·194 ± ·281
Correlation	+ ·551 ± ·031	+ ·455 ± ·034	+ ·388 ± ·043	+ ·405 ± ·041
Numbers	236	247	179	192

The probable errors show that both pilastric and platymeric indices are differentiated with side and sex[1]. Thus combination of sex and side will increase spuriously the correlation. If we combine[2] our material for both sides and sexes, we find the resultant correlation to be + ·510 or an increase of 12 per cent. beyond the weighted mean value of + ·456. Something therefore of the excess in the Alemann and Bavarian correlations is due to this pooling, as well as to the other differences referred to above.

It seems safe to say that *within any individual race*, the correlation of the elliptic tendency in platymeric and pilastric sections is of the order + ·5. We now ask what relations these indices bear to the popliteal index and find them positively, significantly but less substantially correlated with it. Our values are

	♂ R.	♂ L.	♀ R.	♀ L.
Platymeric Index and Popliteal Index ...	+ ·113 ± ·044	+ ·109 ± ·044	+ ·130 ± ·050	+ ·099 ± ·049
Pilastric Index and Popliteal Index ...	+ ·278 ± ·041	+ ·221 ± ·042	+ ·256 ± ·047	+ ·149 ± ·048

We have unfortunately no comparable data, but the above correlations seem sufficient to indicate that the three sections of the shaft tend generally in the same sense, two sections being more alike if they are adjacent. It appears to us that this general tendency of the various sections of the shaft to be apple-shaped, rotund or pear-shaped, rather than the moulding of the sections by *M. glutaeus*, *M. cruralis* or *M. vastus internus*, is the keynote to the relations between the platymeric, pilastric and popliteal indices. According as the pilastric section is like the typical human pilastric—pear-shaped, like the typical gibbon pilastric—rotund, or like the typical gorilloid pilastric—apple-shaped, we may call the shaft pyriform, rotiform or maliform. In numbers we might take pyriform pilastric sections those with index exceeding 102, the maliform those with index under 98, and those between 98 and 102 can be considered rotiform. Primitive races and early man are pyriform on the whole, the

[1] Schwerz does not separate sides, but he gives: Pilastric Index ♂ 106·7, ♀ 103·4 and Platymeric Index ♂ 80·5, ♀ 78·5; thus confirming our conclusion that both indices are higher in male bones.

[2] See Pearson, *Phil. Trans.* Vol. 192 A, p. 277.

anthropoids are maliform, while the Cercopithecidae and the lemurs are rotiform. Modern man is moderately pyriform, with a tendency to the rotiform, which appears to have been already reached by the modern German[1].

When we say that there is a correlation in form between the pilastric and the platymeric or popliteal surfaces we of course do not mean that they are always pyriform or even rotiform when the pilastric section takes these characters. All we understand is that the indices of these two sections will move in sympathy with the index of the pilastric section in the direction of rotundity and pyriformity. For example, we have in our series seven male femora with pilastric indices between 125 and 129, their platymeric indices fall into the groups 91—93 (1), 94—96 (2), 97—98 (1), 100—102 (1), 103—105 (1), 112—114 (1). Thus all are much in excess of the mean male index of 85, and two are actually rotiform and two pyriform.

We ourselves look upon the shaft as a whole and its character whether pyriform, rotiform or maliform as hereditary. Particular types may have been selected because they gave for a special environment or habit a better insertion area for one or other muscle, but the selection of a particular form of subtrochanteric, midshaft or popliteal region would in itself modify the correlated regions[2].

An important question with regard to the correlation of the shaft sections which we have indicated as existing *intraracially* arises when we consider the problem *interracially*[3]. Is there a correlation between the racial mean or type values of the shaft indices?

To answer this question we have only our data in Table VIII. Excluding the apes we have 44 races with platymeric and pilastric indices and 14 with popliteal indices as well. The three interracial correlations are:

Pilastric and Platymeric:	−·0406
Pilastric and Popliteal:	+·2502
Platymeric and Popliteal:	+·1624

The results seem very remarkable.

The interracial correlations for popliteal index with both pilastric and platymeric indices do not sensibly differ from the intraracial values; indeed they are surprisingly close, considering the largeness of error due to paucity of data. The popliteal index is still somewhat more closely related to the pilastric than to the platymeric. But

[1] The Neanderthal-Spy type was rotiform, the Cromagnon type was pyriform; it is possible that this distinction has been maintained in our Londoners and the French as compared with the Germans, but this comparison would not hold for the platymeric indices of these races.

[2] We object just as much to Manouvrier's view of "la saillie pilastrique comme la platymerie produite sous l'influence du muscle crural" or of a portion of the crural muscle altering its "action modificatrice sur le fémur, suivant la nature des occupations et du genre de vie des différents individus" (Bibl. 57, p. 131) as we do to his critic Bumüller's statement that: "die Stenomerie wird durch den Muskeldruck des cruralis hervorgerufen," or that the convexity of the anterior surface can be explained owing to the compression exercised by the muscle, which squeezes the diaphysis in the direction of its transverse diameter (Bibl. 81, S. 53).

[3] For the first introduction of the conceptions involved in intraracial and interracial correlations see *Biometrika*, Vol. I, p. 460.

Racial Correlation of Pilastric and Platymeric Indices.

The broken line is the regression line of Platymeric Index on Pilastric Index for the human portion of the data only.

the interracial value of the correlation between pilastric and platymeric indices is not only reduced to insignificance, but is opposite in sign to the intraracial correlation. We know of such differences between interracial and intraracial in other cases[1], but they are always of marked interest as bearing on the differential selection of race characters by environment and by habits of life necessary to fit that environment. As an interracial character platymery (low index) is just possibly associated with pilastry (high index), while the reverse holds in a high degree inside the race. If we might hazard a suggestion we should incline to believe that both subtrochanteric and mid-shaft regions had been stringently and diversely selected in the modified conditions of the struggle for existence in different parts of the world; but that the popliteal region had been much less stringently selected and had followed in correlated change the changes in the higher regions of the shaft.

The interracial correlationship is exhibited as a "spot diagram" in the chart on the previous page. The regression line obtained is based only on the human elements; it is, perhaps, suggestive that it passes to the centre of the anthropoid apes rather than towards any of the primitive races; these appear more or less as outliers of the main human group rather than as links in a chain of descent from an apelike form to civilised man.

A further interesting point, since the pilaster is peculiar to the upright primate, is the question of how far it is correlated with stature. Now the only measurement we have suggestive of stature in this case, and it is by no means a bad one[2], is that deduced from length of femur. Hence the relation of length of femur to the indices of the cross-sections of the shaft is of some interest. An examination of the BS section of Table II, p. 194, shows that the correlation of platymeric index and maximum length of femur is slight and irregular in sign except in the case of the female left bone where it appears to be significant but small. On the other hand the correlations of pilastric index with maximum length of femur are uniformly positive and two at least are certainly significant. As we can from our data[3] obtain further the correlations of length of shaft with pilastric index we place both series of correlations here for comparison:

Pilastric Index with	♂ R.	♂ L.	♀ R.	♀ L.
Maximum Length of Femur ...	$+ \cdot 102 \pm \cdot 045$	$+ \cdot 204 \pm \cdot 043$	$+ \cdot 121 \pm \cdot 051$	$+ \cdot 282 \pm \cdot 047$
Length of Shaft	$+ \cdot 059 \pm \cdot 043$	$+ \cdot 239 \pm \cdot 043$	$+ \cdot 111 \pm \cdot 051$	$+ \cdot 317 \pm \cdot 050$

Now these results seem of considerable interest. They show (i) that there is no marked relationship between the pilastric index and either length of femur or length of shaft, (ii) that there are distinct differences in the correlation between left and right

[1] See for cranial lengths *Biometrika*, Vol. II, p. 355, and for nasal heights, *Biometrika*, Vol. IX, p. 423.

[2] See Bibl. 79 for correlation of femoral length and stature and our p. 5.

[3] Let S = length of shaft, d_1 = antero-posterior, d_2 = transverse diameter, r = correlation, and V = coefficient of variation, while $i = 100 d_1/d_2$; then $r_{si} = (V_{d_1} r_{sd_1} - V_{d_2} r_{sd_2})/V_i$. Both r_{sd_1} and r_{sd_2} are given in section SS of Table II, p. 195, V_{d_1} and V_{d_2} in Table III of p. 164 and V_i in Table IV, p. 165.

sides, and (iii) probably distinct differences between male and female, the latter being for the same bone in every case more highly correlated. These latter results confirm what we have already stated, *i.e.* that spurious results may be reached by pooling indices for both sexes and both sides.

The first result seems to indicate that neither long femur nor long shaft in themselves produce a marked pilaster, *i.e.* if there be a mechanical influence, such as certain writers have suggested, it is of secondary importance.

More substantial correlations are obtained by correlating the absolute length of the pilastric antero-posterior diameter with the length of shaft[1], *i.e.*

♂ R. + ·263 ± ·042, ♂ L. + ·399 ± ·038, ♀ R. + ·246 ± ·049, ♀ L. + ·459 ± ·040,

but it is difficult to argue more from this than that general increase of size of femur increases both length of shaft and pilastric antero-posterior diameter. At the same time the correlations are distinctly larger between the shaft length and the antero-posterior diameter than between the former and the transverse diameter:

Length of Shaft and Transverse Diameter: ♂ R. + ·193 ± ·043, ♂ L. + ·164 ± ·043, ♀ R. + ·121 ± ·051, ♀ L. + ·108 ± ·050.

On the whole we may conclude that there is some relation between size of femur and the pilastric index and that this is more marked in the influence of size of femur on the antero-posterior than on the transverse diameter. But the influence is not of such intensity that it justifies us in assuming that size of bone or indeed the stature largely influences the development of the pilaster *mechanically*.

If the big individual has on the whole a somewhat higher pilastric index, we may ask if this relationship is maintained when we consider the matter interracially. Have the taller human races more pyriform femora? We have the pilastric and platymeric indices for a number of races in our Table VIII, p. 253. Unfortunately, as we have seen, the bulk of investigators have pooled their data for both sexes, and we are ignorant of the proportions in which they are mixed. Further not all investigators have given the same absolute length of the femur. On examination it appeared that the oblique length was more commonly given. We have accordingly taken as a reasonable indication of the stature of a race the *oblique* length of the *male* femur, and modified the maximum length, when that only has been provided. Our figures are thus only approximate, but amply sufficient to indicate whether there is any close relation between the stature of a race and its platymeric or pilastric mean index.

We find for 44 races:

Interracially, correlation of oblique length of male femur and platymeric index } + ·064.

Intraracially for our Londoners' mean platymeric index and *maximum* length of femur correlation } + ·057.

There is thus possibly a very small positive correlation between length of femur and platymeric index, and this may be taken to be the same intraracially and inter-

[1] It will be seen that the pilastric antero-posterior diameter has like the index increased correlations in the *left* member.

racially. Thus the platymeric races are the slightly shorter races, but the association of platymery with stature is of the slightest. Turning to the pilastric index we have:

Interracially, correlation of oblique length of male femur and pilastric index } $-\cdot114$.

Intraracially for our Londoners' mean pilastric index and maximum length of femur correlation } $+\cdot177$.

Neither of these correlations is very substantial, but there is a great difference between them. Within the race excess of stature is associated with a more marked pilaster, but the short race on the average has more pilaster than the tall race. This interpretation seems borne out by the fact that short races like the Veddahs, Andamans, Negritos have high pilastric indices. But the rule is only an average rule and the correlation is so low that exceptions like the Australians and Patagonians of course occur. The tall modern civilised races are, however, approaching the rotiform femur. It would thus seem that the evolutionary explanation of pilastry must not be sought to any large extent in the need for increased strength to carry the vertical weight imposed on the femur, but may possibly have to be associated with agility in the vertical position whether it be in speed of running, or managing a canoe, etc.

Turning next to the question of the influence of growth on the fundamental indices of the shaft we divided our non-adult 42 femora into three groups: (i) Femora with diaphysial length from 15 to 25 cms.—there were 12 of these with a mean diaphysial length of 21·51 cms. (ii) Femora with diaphysial length greater than 25 cms., but which were not capable, owing to absence of epiphyses, of having neck or maximum length determined. The mean diaphysial length of 13 such femora was 31·2 cms. (iii) Cases in which the neck was capable of measurement but maximum length was impossible (9 cases with mean diaphysial length 37·2) and cases in which the epiphyses were present, but the sutures still open (8 cases reaching up to the mean adult diaphysial length of 38 to 39 cms.). The diaphysial length is here taken from epiphysial border to epiphysial border.

Influence of Age on Fundamental Indices of Shaft[1].

Age Group ♂ + ♀	Platymeric Index	Pilastric Index	Popliteal Index
Epiphyses lacking, Diaphysial Length 25 cms. and under	88·0 [± 1·7]	107·2 [± 1·8]	69·6 [± 1·2]
Epiphyses lacking, Diaphysial Length over 25 cms.	87·4 [± 1·7]	112·1 [± 1·7]	69·9 [± 1·1]
Epiphyses imperfect but neck form with epiphyses formed	84·5 [± 1·5]	106·0 [± 1·5]	72·0 [± 1·0]
Adults (826 to 867)	84·5 [± 0·2]	103·2 [± 0·2]	69·6 [± 0·1]

The probable errors warn us to be careful of laying any great stress on these results. The suggestions which arise are: The platymeric index decreases or platymery increases with age. Pilastry decreases with age; it appears to rise from infancy

[1] Probable errors roughly approximative.

to childhood and then to fall steadily in the adult. It is venturesome to assert anything of the popliteal index, but this like the pilastric *appears* if we could trust the differences to increase with age and then again decrease. To sum up: the shaft of the femur seems to have its minimum of flatness at all three fundamental sections in the adult stage, although its maximum rotundity may be reached in infancy (platymeric index), in childhood (pilastric index), or on approaching the adult stage (popliteal index). In the case of pilastry "maximum rotundity" must be interpreted to mean sagittal oblateness.

The only comparative material I have found is the following:

Bumüller[1] gives some slender data for embryos and children up to 7th—8th year:

Age Group	Platymeric Index	Pilastric Index	Popliteal Index
Diaphysial Length 3 to 8 cms., Mean 6·4 (8 cases)	81·9	98·6	65·5
Diaphysial Length 18·5 to 25·5 cms. Mean 22·2 (5 cases)	83·5	108·2	60·5
Adults (circa 400 cases)	83·9	100·7	68·2

For the pilastric index he obtains a maximum in childhood and a fall to the adult stage, but his other results are not in accordance with our somewhat more ample material. He finds a minimum with childhood in the popliteal index and an increase with age in the platymeric index; the very reverse of our results. But as he includes the gluteal ridge in his platymeric antero-posterior diameter, difference of method may be as influential as the smallness of both our samples. There is but little hope of full light on the manner in which the sections of the shaft change during growth until the material can be increased 10- or 20-fold[2].

[1] Bibl. 81, pp. 85—87.

[2] Rodriguez (Bibl. 101, p. 48) has a very brief sentence in his section "Variations suivant l'âge" (the whole a page in length with no numerical values); he says: "*Les indices pilastrique et platymérique* sont plus élevés chez les jeunes." He had 52 femora non-adult of all kinds of races and he does not say that he has divided them into age groups. Bertaux (Bibl. 52, pp. 210—220) has a number of young (child) femora for which he does not give any pilastric or platymeric indices. On p. 220 he has a table giving means according to age and the entries:

Mean according to Age.

	Under 20	20 to 40	40 to 60	Over 60
Length	374·0	432·4	439·0	429·6
Pilastric Index ...	113·0	102·8	104·7	102·1

But on examining his data pp. 212—215, the first group under 20 appears to consist of the right and left femur of *one* individual (male) aged 18, and therefore we think no statement can be made that this index decreases with age.

NOTE I. TO BROCA'S TABLE (see p. 252).

The following table gives a somewhat wider range than Broca's of the pilastric index in various living forms. In drawing up this table we had hoped that we could take the needful measurements from Dr J. S. Foote's paper, "A Contribution to the Comparative Histology of the Femur[1]," which has at first sight an apparent wealth of information on the midshaft section of the femur in many living forms. The work is edited by Dr A. Hrdlička, and bears the *imprimatur* of Dr Frank Baker, Dr G. A. Piersol and Dr A. Hrdlička himself. But as often as not the sections on the plates (of which no scale is provided) do not agree even relatively with the measurements in the text. In a large number of femora with which we have some familiarity the wrong orientation is given in the plates. In a good many cases the section is cut through the third trochanter without comment, and sometimes the third trochanter may be so orientated as to appear as a pilaster! We might suppose this due to convenience in placing on the plate were it not for the fact that the antero-posterior and transverse (here called lateral) diameters are interchanged in the text itself. This interchange has taken place with regard to a very considerable number of femora we knew well previously or have examined since our suspicions were aroused by the perusal of Dr Foote's memoir. We feel fairly certain of having in the case of the Mammalia discarded the bulk of these erroneous cases, replacing them by larger numbers measured by ourselves. The case is different, however, with the Bats, Amphibians and Reptiles; we are not convinced that the frequent errors found in the field with which we are more familiar may not exist in these groups. Our results therefore for these groups are based merely on Dr Foote's data and cannot be considered final. For Birds we have been able to some extent to check Dr Foote's measurements by measuring 21 avian femora in our own possession. For Man we think it safe to use Dr Foote's data, and they add some interesting material to our series of racial values.

TABLE IX. *The Pilastric Index in Living Forms.*

White Fetus (up to 9 months) (6)	115·3	Man (Foote). Compare: Man (Chief Races of the World) 109·9 (Present Authors) Man (17th century Londoners) 103·02 (Present Authors)
American Indians (Children) (3)	109·1	
American Negroes (25)	109·7	
American Indians (Adults) (19)	102·2	
American Whites (Adults) (68)	101·8	
12th Dynasty Egyptians (7) ...	101·3	

PRIMATES (OTHER THAN MAN).

Anthropoids (19) ...	85·0 (Broca and Foote)	Cebidae and Simiadae (45)	101·1 (Broca and Foote)
„ (187) ...	83·8 (Present Memoir)	„ „ „ (86)	98·3 (Present Authors)
		Lemuroids (42)	100·6 (Present Authors)

[1] *Smithsonian Contributions to Knowledge*, Vol. XXXV, No. 3, pp. 1—231, Washington, 1916.

Amphibians (39)	116·3 (Foote)	Birds (omitting Struthionidae) (37)	104·0 (Foote)
Reptiles (omitting Turtles) (26)	124·3 (Foote)	Birds („ „) (21)	111·3 (Pearson)
Turtles (8)	96·5 (Foote)	Struthionidae (3)	124·9 (Foote)

MAMMALIA (Present Authors + Foote).

Carnivora.	Carnivora vera (61)	93·5	Rodentia.	Simplici dentali (23)	81·9
„	Pinnipedia (1)	50·0		Duplici dentali (2)	75·9
Ungulata.	Artiodactyla, Pecora (26) ...	110·8	Insectivora.	Insectivora vera (10) ...	78·5
„	„ Tragulina (1) ...	107·1		Dermatoptera (1)	118·2
„	„ Tylopoda (2) ...	101·0	Chiroptera (55) (Foote only) ...		114·3
„	„ Suina (4)	112·1	Edentata (15)		69·8
„	Perissodactyla (8)	124·3	Marsupialia (6)		96·6
„	Hyracoidea (2)	91·3	Monotremata.	Echidnidae (2)	47·7
„	Proboscidea (3)	140·2	„	Ornithorhynchidae (2) ...	70·0

The main feature of a table like the present is the evidence that it provides of man's unique position in pilastric index. The other anthropoids do not approach him. We have to ascend to the Old World monkeys and the Lemuroids to reach a mean pilastric index over 100, and then the source of this value is not usually the same as that of the still higher index in Man. It arises from a rotiform not a pyriform pilastric section. Even when we get, as in the Birds or Pecora, an index as high or higher than in Man, the source lies in a rotiform section being extended antero-posteriorly to an elliptic section, and not in the development of the characteristically human pyriform section. To find traces of this we must search among the lesser apes and anthropoids, and the traces are not very marked then. Indeed, the rotiform section is still by no means a scarce variety in Recent Man, and in almost any long series of femora we can mark both rotiform and pyriform pilastric sections. The pyriform section, we have suggested, came in fairly rapidly with Cromagnon Man; the present mixture is hardly explicable without postulating a fairly recent ancestor with a roughly rotiform pilastric section—a direct descent from or at least a hybridisation by a Neanderthal type.

Any interpretation, however, of such a table as the present which does not distinguish between 110 in Man and in Pecora is foredoomed to failure. The high pilastric index of Man screens an almost unique development from the anthropoid stem; the high value in Pecora is most probably a vestige of a much earlier living form.

NOTE II. Correlations of Platymeric, Pilastric and Popliteal Indices having regard to Side and Sex. For reference see p. 262. We place here the tables on which these correlations are based.

(i) *Platymeric Index.* ♂ R.

Pilastric Index	63·5– 66·5	66·5– 69·5	69·5– 72·5	72·5– 75·5	75·5– 78·5	78·5– 81·5	81·5– 84·5	84·5– 87·5	87·5– 90·5	90·5– 93·5	93·5– 96·5	96·5– 99·5	99·5–102·5	102·5–105·5	105·5–108·5	108·5–111·5	111·5–114·5	114·5–117·5	Totals
74·5– 79·5	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
79·5– 84·5	—	—	1	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	2
84·5– 89·5	—	2	—	3	—	1	—	1	—	—	—	—	—	—	—	—	—	—	7
89·5– 94·5	1	—	4	4	3	4	2	2·5	·5	—	—	—	—	—	—	—	—	—	21
94·5– 99·5	—	—	1	2	5	5	7	2	1	1	—	—	—	—	—	—	—	—	24
99·5–104·5	—	—	1	3	7	8	9	7	3	4·5	1·5	1	2	—	—	—	—	—	47
104·5–109·5	1	—	—	2	4	5	8	12·5	4·5	4	2	3	3	1	—	—	—	—	50
109·5–114·5	—	—	1	3	1·5	3	5	4·5	6	8	2	4	2·5	1	1	—	—	—	42·5
114·5–119·5	—	—	—	1	1·5	1	2·5	5	6	4	2	1	5·5	—	—	—	—	—	29·5
119·5–124·5	—	—	—	—	—	—	1	2	1	1	1	—	—	—	1	—	—	—	7
124·5–129·5	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	1	—	3
129·5–134·5	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	1
134·5–139·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0
139·5–144·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0
144·5–149·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1
Totals ...	2	2	9	18	22	27	34·5	37·5	23	23·5	9·5	9	13	2	2	0	1	1	236

(ii) *Platymeric Index.* ♂ L.

Pilastric Index	66·5– 69·5	69·5– 72·5	72·5– 75·5	75·5– 78·5	78·5– 81·5	81·5– 84·5	84·5– 87·5	87·5– 90·5	90·5– 93·5	93·5– 96·5	96·5– 99·5	99·5–102·5	102·5–105·5	105·5–108·5	108·5–111·5	111·5–114·5	Totals
74·5– 79·5	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	1
79·5– 84·5	1	·5	3·5	—	1	1	—	—	—	—	—	—	—	—	—	—	7
84·5– 89·5	—	1	2	2·25	2·25	1	1	—	1	—	—	—	—	—	—	—	10·5
89·5– 94·5	3	1·5	3·5	6·25	1·25	2	3	3	1	1	—	—	—	—	1	—	26·5
94·5– 99·5	5	1	3	5	5	5	3	2	2	1	—	—	—	1	—	—	33
99·5–104·5	—	—	2	6·5	7·5	14	12	6	5	4·5	3·5	1	—	—	—	—	62
104·5–109·5	1	1·5	3·5	1	8	8·5	3·5	4·5	6·5	1·5	1·5	2	2	—	—	—	45
109·5–114·5	1	1	1	3	3	3	4	5	3	4	3·5	2	1	1	—	—	35·5
114·5–119·5	—		—	—	·5	4·5	5	1	—	2	·5	—	—	2	1	1	17·5
119·5–124·5	—	—	—	1	—	—		-	1	·5	-	1·5	·5	—	1	—	5·5
124·5–129·5	—	—	—	—	—	—		—	—	·5	1	1·5	·5	—	—	—	3·5
Totals ...	11	6·5	18·5	25	28·5	39	32·5	21·5	19·5	15	10	8	4	4	3	1	247

(iii) *Platymeric Index.* ♀ R.

Pilastric Index	64– 66	67– 69	70– 72	73– 75	76– 78	79– 81	82– 84	85– 87	88– 90	91– 93	94– 96	97– 99	100–102	103–105	106–108	109–111	112–114	115–117	Totals
75– 79	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1
80– 84	—	·5	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	2·5
85– 89	—	·5	1	1	1	—	—	1	1	1	—	—	—	—	—	—	—	—	6·5
90– 94	1	2	2	2	2	3	3	—	1	—	—	—	—	—	—	—	—	—	16
95– 99	—	—	4	4	2	5	4	1	1	1	2	—	—	—	—	—	—	—	24
100–104	—	1	4	2	5	9·5	9·5	4	2	6	3	1	1	1	—	—	—	—	49
105–109	—	1	—	1	4	3·5	5·5	1·5	4·5	1	2	1	1	—	—	—	—	1	27
110–114	—	—	1	—	4	4	5	3	8	5	2	—	—	2	—	—	—	1	35
115–119	—	—	—	—	4	1	1	3	1	—	1	1	—	—	—	—	—	—	12
120–124	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	2	3
125–129	—	—	—	1	—	—	—	—	—	1	—	—	—	—	—	—	—	—	2
130–134	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	1
Totals ...	1	5	12	11	22	26	29	15·5	18·5	15	10	3	2	3	1	1	0	4	179

(iv) *Platymeric Index.* ♀ L.

Pilastric Index	64–66	67–69	70–72	73–75	76–78	79–81	82–84	85–87	88–90	91–93	94–96	97–99	100–102	103–105	106–108	109–110	Totals
65–69	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	1
70–74	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0
75–79	—	—	—	—	1	—	1	—	—	—	—	—	—	—	—	—	2
80–84	—	1	1	1	4	—	1	—	—	—	—	—	—	—	—	—	8
85–89	—	1	1	5	5	3	1	1	1	1	—	1	—	—	—	—	20
90–94	2	—	3	3	10	2	4·5	2·5	—	—	1	—	—	—	—	—	28
95–99	—	—	3	4	4	6·5	4·5	3	—	1	1	1	—	—	—	—	28
100–104	—	—	6	5	6	4	12	5	6	5	—	—	1	—	—	—	50
105–109	—	·5	—	4	5	4·5	1·5	5	3	3	1	1	1	—	1	1	31·5
110–114	—	·5	—	1	—	1	—	5	—	3	—	—	—	—	1	—	11·5
115–119	—	—	—	—	—	3	2	—	1	—	—	1	1	—	1	—	9
120–124	—	—	—	—	—	—	1	—	—	2	—	—	—	—	—	—	3
Totals ...	2	3	14	24	35	24	28·5	21·5	11	15	3	4	3	0	3	1	192

(v) *Pilastric Index.* ♂ R.

Popliteal Index	74·5–79·5	79·5–84·5	84·5–89·5	89·5–94·5	94·5–99·5	99·5–104·5	104·5–109·5	109·5–114·5	114·5–119·5	119·5–124·5	124·5–129·5	129·5–134·5	134·5–139·5	139·5–144·5	144·5–149·5	Totals
49·5–53·5	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1
53·5–57·5	—	—	—	1	—	·5	—	—	—	—	—	—	—	—	—	1·5
57·5–61·5	—	—	—	1·5	3	6	3	1	—	—	—	—	—	—	—	14·5
61·5–65·5	1	1	3	2·5	4	6	4·5	1·5	1	—	—	—	—	—	—	24·5
65·5–69·5	—	1	1	6	5	14·5	16	11	8	—	—	—	—	—	—	62·5
69·5–73·5	—	—	1	3	8	9	6·5	10·5	6	2	—	—	—	—	1	47
73·5–77·5	—	—	2	5	—	2	11	11·5	6	3	1	—	—	—	—	41·5
77·5–81·5	—	—	—	1	3	4	4	3·5	5·5	—	—	1	—	—	—	22
81·5–85·5	—	—	—	—	2	2	2	1·5	·5	—	—	—	—	—	—	8
85·5–89·5	—	—	—	—	—	—	1	—	·5	—	—	—	—	—	—	1·5
89·5–93·5	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	1
Totals ...	1	2	7	21	25	44	49	40·5	27·5	5	1	1	0	0	1	225

(vi) *Pilastric Index.* ♂ L.

Popliteal Index	74·5–79·5	79·5–84·5	84·5–89·5	89·5–94·5	94·5–99·5	99·5–104·5	104·5–109·5	109·5–114·5	114·5–119·5	119·5–124·5	124·5–129·5	Totals
49·5–52·5	—	—	—	1	—	—	—	—	—	—	—	1
52·5–55·5	—	—	—	—	—	2	—	—	—	—	—	2
55·5–58·5	—	—	—	—	2	—	1	·5	·5	—	—	4
58·5–61·5	—	2	·25	1·25	2	1	3	—	—	—	—	9·5
61·5–64·5	—	—	2·25	2·25	3	4	4	2	1	—	—	18·5
64·5–67·5	1	—	2	3	4	13	5·5	2	1	1	—	32·5
67·5–70·5	—	1	1	5	5	11·5	7·5	4	2	·5	1·5	39
70·5–73·5	—	4	3	3	4	9·5	7	4	6·5	·5	·5	42
73·5–76·5	—	—	1	4	6	6	6·5	8·5	3·5	1	—	36·5
76·5–79·5	—	—	—	3	2	7	6·5	6·5	2	1	1	29
79·5–82·5	—	—	—	1	1	5	3	2	—	·5	·5	13
82·5–85·5	—	—	—	1	1·5	—	—	3	—	1	—	6·5
85·5–88·5	—	—	—	—	·5	—	—	1	—	—	—	1·5
Totals ...	1	7	9·5	24·5	31	59	44	33·5	16·5	5·5	3·5	235

(vii) *Popliteal Index.* ♀ R.

Pilastric Index	53–55	56–58	59–61	62–64	65–67	68–70	71–73	74–76	77–79	80–82	83–85	86–88	Totals
75– 79	—	—	—	—	—	—	1	—	—	—	—	—	1
80– 84	—	1	—	1·5	—	—	—	1	—	—	—	—	3·5
85– 89	—	—	·5	3	—	1	1	—	—	—	—	—	5·5
90– 94	1	2	3	2	2	2	2	1	1	—	—	—	16
95– 99	—	—	3	8	4	6	1	2	2	—	—	—	26
100–104	—	2·5	5	13·5	11·5	11·5	3	2	—	—	—	—	49
105–109	—	1	1	6	8	4	5·5	1·5	1	—	—	1	29
110–114	—	2·5	2·5	5	5·5	7·5	5	1·5	1·5	—	1	—	32
115–119	—	1	—	—	2	3	3	1	2	—	—	—	12
120–124	—	—	—	—	2	—	—	1	—	—	—	—	3
125–129	—	—	—	—	—	1	—	1	—	—	1	—	3
130–134	—	—	—	—	—	—	—	1	—	—	—	—	1
Totals ...	1	10	15	39	35	36	21·5	13	7·5	0	2	1	181

(viii) *Popliteal Index.* ♀ L.

Pilastric Index	56–58	59–61	62–64	65–67	68–70	71–73	74–76	77–79	80–82	83–85	Totals
75– 79	—	—	2	—	—	—	—	—	—	—	2
80– 84	—	1	—	3	1	1	1	—	—	—	7
85– 89	—	3	4	4	3	3	2	—	—	—	19
90– 94	—	2	5	4	5	6	3·5	1·5	1	—	28
95– 99	1	2	2	6	7	4	4	3	—	—	29
100–104	1	5	5	10	11	4	7	1	4	—	48
105–109	1	3	4	7·5	3	2	4	2	4	—	30·5
110–114	—	—	—	4·5	—	3·5	·5	1	—	—	9·5
115–119	—	—	1	3	1	1·5	1·5	—	·5	·5	9
120–124	—	—	—	—	1	2	—	—	—	—	3
Totals ...	3	16	23	42	32	27	23·5	8·5	9·5	0·5	185

(ix) *Platymeric Index.* ♂ R.

Popliteal Index	63·5– 66·5	66·5– 69·5	69·5– 72·5	72·5– 75·5	75·5– 78·5	78·5– 81·5	81·5– 84·5	84·5– 87·5	87·5– 90·5	90·5– 93·5	93·5– 96·5	96·5– 99·5	99·5–102·5	102·5–105·5	105·5–108·5	108·5–111·5	111·5–114·5	114·5–117·5	Totals
49·5–53·5	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	1
53·5–57·5	—	—	—	—	—	1	·5	—	—	—	—	—	—	—	—	—	—	—	1·5
57·5–61·5	—	—	·5	—	1	3·5	3·5	2	1	1	—	1	—	—	—	—	—	—	13·5
61·5–65·5	—	1	2·5	3	4	3·5	2	3	2	—	1	—	2·5	—	—	—	—	—	24·5
65·5–69·5	2	—	2	6·5	7	4	7	9	4·5	8	2	4	4·5	1	1	—	—	—	62·5
69·5–73·5	—	—	—	4·5	6	6	8	6·5	4	5	2	2	1	—	1	—	—	1	47
73·5–77·5	—	1	2	2·5	1·5	4	9	7	5	4	1	1	3·5	—	—	—	—	—	41·5
77·5–81·5	—	—	1	·5	1·5	4	2·25	3·75	3·5	2	1	—	1·5	1	—	—	—	—	22
81·5–85·5	—	—	—	—	1	1	2·25	1·25	—	1	·5	1	—	—	—	—	—	—	8
85·5–89·5	—	—	—	—	—	—	—	1	—	·5	—	—	—	—	—	—	—	—	1·5
89·5–93·5	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	1
Totals	2	2	8	17	22	27	34·5	34·5	20	21·5	8·5	9	13	2	2	0	0	1	224

(x) *Platymeric Index.* ♂ L.

Popliteal Index	66·5– 69·5	69·5– 72·5	72·5– 75·5	75·5– 78·5	78·5– 81·5	81·5– 84·5	84·5– 87·5	87·5– 90·5	90·5– 93·5	93·5– 96·5	96·5– 99·5	99·5–102·5	102·5–105·5	105·5–108·5	108·5–111·5	111·5–114·5	Totals
49·5–52·5	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	1
52·5–55·5	—	—	—	—	1	—	—	—	—	1	—	—	—	—	—	—	2
55·5–58·5	—	—	—	1	1	—	—	—	—	—	1	1	—	—	—	—	4
58·5–61·5	—	·5	1·5	1·25	1·25	1·5	2·5	—	1	—	—	—	—	—	—	—	9·5
61·5–64·5	2	—	3	2·25	3·25	1	3	2	—	3	—	—	—	—	—	—	19·5
64·5–67·5	1	1	1	3	6	8·5	5	2	1	—	1	1	—	—	2	—	32·5
67·5–70·5	—	—	4	5·5	7·5	2·5	6·5	5	4	—	2	—	1	1	—	—	39
70·5–73·5	4	1	4	6	3	8	4·5	3	5	1	1	—	—	1	—	·5	42
73·5–76·5	1	1·5	1·5	3	3	6·5	7	2	1	3·5	1·5	2	1·5	—	—	·5	35·5
76·5–79·5	2	1	1	1	1·5	6	1	5	2	4·5	1·5	2	·5	—	—	—	29
79·5–82·5	—	·5	1·5	1	—	2	—	·5	2·5	—	1	1	1	1	—	—	12
82·5–85·5	1	·5	—	—	—	2	—	1	1	—	—	—	—	—	—	—	5·5
85·5–88·5	—	·5	—	—	—	—	1	—	—	—	—	—	—	—	—	—	1·5
Totals	11	6·5	17·5	25	27·5	38	30·5	20·5	17·5	13	9	7	4	3	2	1	233

(xi) *Platymeric Index.* ♀ R.

Popliteal Index	64– 66	67– 69	70– 72	73– 75	76– 78	79– 81	82– 84	85– 87	88– 90	91– 93	94– 96	97– 99	100–102	103–105	106–108	109–111	112–114	115–117	Totals
53–55	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
56–58	—	—	1	—	1·5	2	3	1	—	—	·5	—	—	—	—	—	—	1	9
59–61	—	—	3	—	3	2	2·25	1·25	1	—	1·5	—	—	—	—	—	—	1	15
62–64	—	3	3	2	1·5	6	7·75	4·75	2	2	2	—	1	2	—	—	—	—	37
65–67	—	2	2	3	7	4·5	4·5	—	1	3	3	2	1	—	—	1	—	1	35
68–70	—	—	3	1	2	6	4	2·5	6·5	4	3	1	—	1	—	—	—	—	34
71–73	—	—	—	—	3	2·5	5	3	5	2	—	—	—	—	—	—	—	—	20·5
74–76	—	—	—	3	1	3	·5	1	—	2	—	—	—	—	1	—	—	1·5	13
77–79	—	—	—	—	2	—	1	1·5	1·5	—	—	—	—	—	—	—	—	·5	6·5
80–82	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0
83–85	—	—	—	—	—	—	—	·5	·5	—	—	—	—	—	—	—	—	—	1
86–88	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Totals	1	5	12	10	21	26	28	15·5	17·5	13	10	3	2	3	1	1	0	4	173

(xii) *Platymeric Index.* ♀ L.

Popliteal Index	64– 66	67– 69	70– 72	73– 75	76– 78	79– 81	82– 84	85– 87	88– 90	91– 93	94– 96	97– 99	100–102	103–105	106–108	109–111	Totals
56–58	—	—	1	—	—	—	1	—	—	1	—	—	—	—	—	—	3
59–61	—	1	2	3	3	1	1	3	1	—	—	1	—	—	—	—	16
62–64	—	—	1	6	7·5	2·5	1·5	2	·5	3	—	—	—	—	—	—	24
65–67	—	1	2	5	5·5	9	5	4·5	3·5	3	—	—	·5	—	2	1	42
68–70	—	—	—	6	5	5·5	6	3	2	1	—	—	2·5	—	—	—	31
71–73	1	1	4	2	5	1	4	3	1·5	3·5	1	—	—	—	—	—	27
74–76	1	—	2·5	1	4	3	5	2	1·5	1·5	1	1	—	—	—	—	23·5
77–79	—	—	·5	—	2	—	2	—	1	—	1	1	—	—	—	—	7·5
80–82	—	—	1	—	1	·5	1	3	—	1	—	1	—	—	—	—	8·5
83–85	—	—	—	—	—	·5	—	—	—	—	—	—	—	—	—	—	0·5
86–88	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0
89–91	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0
Totals	2	3	14	23	33	23	26·5	20·5	11	14	3	4	3	0	2	1	183

VII. *The Bowing of the Femur.*

We were able to measure the indices of bowing in 41 young bones. In 25 of these the epiphyses were absent, and the neck was so little developed that no neck measurements could be taken. In 9 bones, although the epiphyses were absent or in part absent so that no length could be taken, the neck was formed, so that neck measurements were possible. In 7 bones the epiphyses were present so that the maximum length could be taken, but the epiphyses were not fully fused. We were thus able to make five broad age divisions, each containing, however, only roughly seven bones. The results were as follows:

	Age Group. Both Sexes	Primary Index of Bowing	Secondary Index of Bowing
A	No Epiphyses, Diaphysial Length* < 25 cms. ...	2·45	37·14
B	,, ,, ,, 25 to 30 cms.	2·78	39·05
C	,, ,, ,, > 30 cms. ...	3·03	40·14
D	Epiphyses imperfect, Neck formed	2·89	35·20 } 40·63
E	Epiphyses formed	2·61	47·60 }
F	Adult Bones ♂ (R. + L.)	2·55	37·85
F′	,, ,, ♀ (R. + L.)	2·50	41·14

* This is not the diaphysial chord used in our index of bowing, *i.e.* the distance from platymeric to popliteal section, but the length from epiphysial border to epiphysial border taken as accurately as the case permitted with the tape or calipers. In determining the bowing chord the popliteal section was taken at $\frac{1}{10}$ of this diaphysial length from the epiphysial border.

If these figures for non-adults could be considered as based on numerically adequate data—which is far from the case—we should conclude that bowing increases from infancy through childhood to about four years of age and then diminishes to the adult condition when it has again about the infantile value. Whether there is a real maximum of bowing at about four years of age seems to us doubtful even if the above numbers are valid, because it is more than probable that our sample of children is not a random selection, but that the individuals who die in childhood have on the whole less healthy and normal bones. We believe that Guldberg[1] is incorrect in speaking of a flat femur as of *infantile type*; it is very difficult to appreciate the curvature in a very short length, and naturally if he has judged as appears by the subtense only, this would be much smaller for an infantile bone than an adult one. We cannot accept the position that the eye can judge a "flat" bone; the length of the arc makes a very appreciable difference in our judgment of its curvature, and we believe that without actually determining the ratio of subtense to chord, it is not safe to appreciate bowing by the eye. If R be the radius of curvature of the diaphysis, A_1 the diaphysial chord, A_2 the diaphysial subtense, then if we assume with Antony and Rivet[2] that the bowing is in a circle, we have

$$R = \tfrac{1}{2} A_2 + \tfrac{1}{8} A_1^2/A_2 = 12{\cdot}5 A_1/B$$

[1] Bibl. 93, S. 295. [2] Bibl. 97.

nearly, where B is the index of bowing. Thus if R is to become infinite or the curvature zero with infancy, we must have, since A_1 becomes smaller and smaller, the index of bowing B decreasing as we go back at a very rapid rate. We do not, however, find this to be the case; the index of bowing remains relatively constant and the chord increases rapidly with age. Thus R is greater for the adult than the child or the curvature is less[1]. We have as a matter of fact for our five groups in terms of curvature:

Children under 5 years	A	·0115	·0110 cm.$^{-1}$.
	B	·0116	
	C	·0100	
Neck or Epiphyses formed	D	·0095	·0094* cm.$^{-1}$.
	E	·0094	
Adults	F		·0083 cm.$^{-1}$ (according to our data). ·0097 cm.$^{-1}$ (according to Antony and Rivet).

* Guldberg (Bibl. 93, S. 296) found the curvature in children of 8 to 12 the same as that of adults.

It appears to us therefore that absence of bowing as a mark of *infancy* is an incorrect conception. At the same time we have only very slender data for fetal bowing. The fetal femur has been asserted to be straight, but we are inclined to believe that the judgment of its flatness has probably been made like that of the

[1] There is a good deal of confusion in the anatomical or anthropometric use of the word curvature. It often appears to refer to the radius of curvature R and not to the mathematical curvature $1/R$. Antony and Rivet take the mean R; but do not appear to recognise that the inverse of the mean R is not the mean curvature, *i.e.* mean value of $1/R$, although their conclusions are drawn in terms of curvature. Thus the 26 gorilla femora they give have a mean curvature of ·0139, the inverse of which is 71·9 cms., while the mean radius of curvature is 79·8 cms. [A. and R. give it as still higher, 84·1, but this arises from their using the mean radius only in the case of *paired* bones]. The difficulty is admirably illustrated in the case of the gibbons, where two out of 15 femora are said to have $R = \infty$. The mean value of R is accordingly infinite and the inverse of mean R would be zero. Thus these two femora must either be arbitrarily omitted, or more refined measurements taken to find their R. If we take the *curvature*, the mean value for the 15 gibbons is ·005354, corresponding to an inverse of mean curvature of 186·8 *cms.*—a radius higher than that of the gorillas, but by no means infinite. Had we taken the mean radius of curvature of the 13 finite values the result would have been 287·3 cms. The same 13 give for mean curvature the value ·006178, leading to an inverse of 161·9 cms. It will be seen from this illustration that if curvature and not an index of bowing is to be adopted we can only avoid asserting that the gibbons have an infinite mean radius of curvature by starting with the curvatures and not the radii of curvature. In this case according to the data of Antony and Rivet the

mean curvature of	the femur in	Man	... = ·0096*
,,	,,	Woman	= ·0097
,,	,,	the Gorilla	= ·0139
,,	,,	the Gibbon	= ·0054

while infants and children under five give according to our data a value of about ·0110. It will be seen that if the infant be nearer to the gorilla, the adult is nearer to the gibbon, and we have another case—if it be in an inverse manner—of what has been termed the "scission qui se fait dans l'ordre des Primates."

* Using mean values our results give in Man ·0079, in Woman ·0087. The differences must be racial; they can scarcely be due to the fact that we have worked with the diaphysial chord from popliteal to platymeric section, while Antony and Rivet take the entire diaphysial length. For, owing to the flattening of the anterior face as we approach the epiphyses, A_2 is increased while A_1 remains nearly constant, thus R would be exaggerated and their curvature $1/R$ diminished. As we have already indicated, the secondary index of bowing shows the unsatisfactory character of R.

infant on the smallness of the subtense[1]. Extreme bowing in cases of rachitis may be due to mechanical influences, but that bowing in the normal human being is a product of the weight of the body seems incompatible with the decrease of curvature with the approach to adult life.

Guldberg has considered without providing quantitative determination the skewness of the bowing. He writes: "diese Krümmung hat gewöhnlich ihre grösste Hohe ungefähr in der Mitte oder etwas näher dem proximalen Ende, dagegen viel seltener näher dem distalen Ende[2]."

Our secondary index of bowing has been devised to describe this skewness adequately. It will be seen that the point of maximum curvature divides the diaphysial chord in about the ratio of 2 to 3, so that point is substantially nearer the proximal end, certainly this point is not "ungefähr in der Mitte." Our data only shows 4·4 °/₀ of male bones with the maximum of curvature nearer the distal end, and 14·7 °/₀ of female bones. This apparent sexual difference is marked by secondary indices of

[1] *Bowing of the Fetal Femur.* We do not know how bowing has been measured on the fetal femur by others. The bones of the fetal skeleton are so plastic and liable to set and distort in the process of mounting that little confidence can be placed in measurements made upon the dry fetus as representing the actual fetal condition. Further the quantities to be measured are so small that great errors are likely to occur. Accordingly every one of the present values is to be considered extremely doubtful. Taken as a whole, however, they do not seem to support the view that the fetal femur is *flat.* Our measurements were made by taking a thin bit of lead ribbon, cutting off a length equal to the distance between the assumed popliteal and platymeric sections, bending this to the anterior surface of the femur, then placing it on its edge on a sheet of paper and drawing the curved line of the anterior face from this lead ribbon with a fine pencil on the paper. The chord and subtense of this arc were then measured and the distance of the subtense from the proximal end of the chord. We have to thank Professor Wood Jones for most kindly placing six dry preparations at our disposal.

First Fetus, R. and L. Diaphysial Length 6·90 cms. The torsion is so great that the plane of the anterior face at the proximal epiphysis border is rotated so as to be almost perpendicular to the plane of the anterior face at the distal epiphysis border. This rotation brings the mesial boundary of the upper half of the anterior face into the sagittal plane of the lower half of the anterior face, and the lead strip has either to be given a double curvature in space, or will show even a slight negative curvature when brought against the mesial boundary. This torsion formed a difficulty—although not so complete—in other cases and the position of the lead ribbon had to be a compromise.

Second Fetus, R. and L. Diaphysial Length 6·41 cms. Primary Index of Bowing, R. 2·56, L. 2·34; Secondary Index, R. 50·0, L. 60·0.

Third Fetus, R. and L. Diaphysial Length 5·23 cms. Primary Index of Bowing, R. 2·29, L. 2·26; Secondary Index, R. 48·0, L. 48·0.

Fourth Fetus, R. and L. Diaphysial Length 4·40 cms. Primary Index of Bowing, R. 3·21, L. 3·17; Secondary Index, R. 57·1, L. 42·1.

Fifth Fetus, R. and L. Diaphysial Length 3·30 cms. Primary Index of Bowing, R. 3·71, L. 2·92; Secondary Index, R. 36·75, L. 35·67.

Sixth Fetus, R. and L. Diaphysial Length 2·65 cms. Primary Index of Bowing, R. 4·44, L. 4·00; Secondary Index, R. 66·7, L. 46·7.

Mean Fetal Primary Index of Bowing 3·09, Mean Secondary Index 48·7.

We believe that the sole reliable inferences to be drawn from these results are (i) that the fetal femur is not flat and (ii) that the point of maximum bowing is near the middle of the shaft—perhaps more nearly so than later in life.

[2] Bibl. 93, S. 294.

bowing of 37·85 and 40·14 respectively. Thus the curvature of the female thigh-bone reaches its maximum at a slightly lower point than the male, but on the other hand it appears to be slightly less (primary indices 2·57 and 2·49 respectively). The mean secondary index for children's bones is 39·98, which lies between the results obtained for male and female adults and very near their mean 39·49, and is therefore compatible with no change in this index with growth. The results for the non-adult bones are somewhat erratic, but there is some indication of increase of index with age, or a suggestion that the proximal end might develop more rapidly than the distal if we suppose the point of maximum curvature not to shift relative to the material of the shaft[1]. The series is too slender, however, for us to risk more than a suggestion.

Guldberg[2], judging from Dubois' plates, considers the femur of *Pithecanthropus* to be of "infantile type," *i.e.* to be flat. The indices of bowing are, as far as can[3] be determined from the photographs:—Primary: 2·76, Secondary: 51·7, and do not seem peculiarly "infantile" or indeed flat.

In attempting to compare our results with those of Antony and Rivet[4] we meet with many difficulties. In the first place they use the radius of curvature R obtained from the formula $R = (A_1^2 + 4A_2^2)/(8A_2)$, a formula which wholly neglects the fact that the secondary index of bowing is far from 50. In the next place their frequency distributions being:

R =	50–70	70–90	90–100	100–130	130–150	150–170	170–190	190–210	210–230	230–250	250–270	Totals
♂	2*	16	14	12	7	4	—	2*	1*	1*	—	59
♀	4	9	9	6	3	3	4	—	1*	—	1*	40

they eliminate the eight femora we have marked with asterisks as being non-continuous with the rest of their frequency distributions. But such discontinuity must always occur with small samples, and although they may have other reasons

[1] This appears contrary to the usual statement that growth in length of femur takes place chiefly from the lower epiphysis (Gray's *Anatomy*, 17th edn., 1909, p. 340), but it must be remembered that our method of obtaining the curvature excludes from consideration the flatter portions of the shaft in the immediate neighbourhood of the epiphyses, and when these are included, the relative growth may be much modified. See however the footnote on the previous page as to the fetal secondary index.

[2] Bibl. 93, S. 298.

[3] As far as we can judge both the photograph (S. 17, Fig. 3*b*) and the plate (Pl. II, Fig. 2) of Dubois' monograph (Bibl. 67 *bis*) lead to the same results, *i.e.* a diaphysial chord of 29 cms. and a diaphysial subtense of 0·8 cm.—both measured in our manner. According to these our index of bowing for the Trinil femur would be 2·76 and the curvature in Antony and Rivet's sense would be ·0076. The modern human femur with which the Trinil femur is compared (S. 17) has an index of bowing of about 3·00 and a curvature of about ·0086. As far as it is possible to estimate on these photographs, the secondary indices of bowing are 51·7 and 35·7 for the Trinil and modern human femora respectively. It is rather the secondary than the primary index of bowing which is noteworthy in the Trinil femur but neither index is beyond the range of very common values in the human femur. Probably the comparison with a rather more bowed femur on S. 17 of Dubois' monograph, and his remark on S. 18 ("Das Mittelstück ist etwas weniger convex nach vorne gebogen als beim Menschen") has led to a somewhat hasty assumption that there is an absence of any bowing.

[4] Bibl. 97.

not stated, one cannot legitimately discard these measurements on the ground merely of discontinuity[1]. Further their material is racially very different from ours, consisting of 100 femora of prehistoric Columbian Indians.

Using their material we find for the radius of curvature in cm. units[2]:

		Mean	Standard Deviation
Columbian Indians	♂	114·0	35·73
	♀	118·5	44·53

The female is thus more variable and has a slightly flatter femur than the male. We can now compare these conclusions with our own results[3].

Character	Sex	Bone	Number	Mean	Standard Deviation
Primary Index of Bowing	♂	R.	234	2·587 ± ·031	·699 ± ·022
	♂	L.	242	2·515 ± ·029	·660 ± ·020
	♀	R.	172	2·503 ± ·037	·716 ± ·026
	♀	L.	189	2·501 ± ·033	·673 ± ·023
Secondary Index of Bowing	♂	R.	240	37·09 ± ·29	6·74 ± ·21
	♂	L.	242	38·60 ± ·33	7·57 ± ·23
	♀	R.	170	39·47 ± ·48	9·27 ± ·34
	♀	L.	190	42·62 ± ·44	8·99 ± ·31

We see at once that in the primary index of bowing the differences between male and female both in mean and variability are of the order of the probable error of the differences. The differences such as they are indicate that the female femur is less bowed and more variable than the male—which is in agreement with Antony and Rivet's far more slender data[4]. But, having regard to the probable errors, the difference if any is so slight that far more material would be needful before any definite assertion could be made, and then so slender a distinction could not be used as a classificatory sex difference. On the other hand we are justified in asserting that the point of maximum curvature of the anterior surface of the femur is more median in the female than the male and that the position of it is more variable. Here again the differences although quite significant form only an average class distinction and would be of small service for differentiating individual bones.

[1] *Loc. cit.* p. 232.

[2] From smaller grouping than above.

[3] The only comparable data beyond those considered above are due to Mollison (Bibl. 100, p. 588). He has quite sound views of how bowing is to be determined, and we think if his method of determining the proximal end of his diaphysial chord be not absolutely identical with ours still his index of bowing is quite reasonably comparable. Unfortunately his material is of the slenderest; he gives for six unsexed Maori femora, R. + L.: Index of Bowing 2·48 (range 1·4 to 3·4). On this evidence there is apparently no difference in the extent of bowing between a primitive race like the Maori and our 17th century Londoners.

[4] On the other hand if we treat the *curvature* obtained from the mean values of subtense and chord we find: Men ·0079 and Women ·0087, *i.e.* the women have more curvature, or using Antony and Rivet's process, we get the *opposite* of their result. We do not think there is any real sexual differentiation.

We are able on the basis of the above data to consider Antony and Rivet's further statement that the bowing is greater in the right than the left bone. If we were to trust to our decimal places this would be a correct assertion, but the probable errors show that no credit can be given to the second, much less the third place of decimals. Thus the only conclusion we can base on our data is that if there be a real distinction between the curvature of right and left femur our material and therefore *a fortiori* Antony and Rivet's is too inadequate to demonstrate its existence[1]. On the other hand the left femur has its point of maximum curvature on the average in a position further removed from the proximal epiphysis than the right. This is significant having regard to the probable error of the difference in both male and female. In the case of both indices for three cases the right bone is more variable than the left, but the differences are not significant with regard to the probable error of the differences. In the fourth case, that of the male secondary index where the difference (·83) is more than 2·5 times the probable error (·31), and we might begin to suspect significance, the left is more variable than the right, and we must accordingly conclude that our data do not suffice to show that as a rule right or left side has a preponderating variability.

Antony and Rivet now proceed to a number of conclusions bearing on the possibility of a mechanical origin of the flexure. Following Manouvrier they seem inclined to reject theories of any mechanical origin. Manouvrier had stated that there was no bowing in children—a conclusion with which we are unable to agree—and had attributed bowing in general to a "compensating effect," corresponding to a development of the pilaster, due to the extension of the surface of insertion of the crural muscle[2]. It will be seen that this attitude is one with that which attributes the development of the third trochanter and the *fossa hypotrochanterica* to direct muscular action. Difficulties arise, suggested partly by supporters of the older mechanical theory who point to the bowing which so often is associated with rachitic and non-muscular bones, and partly by those who draw attention to the bowing in the case of the apes where there may be bowing and no pilaster to require "compensating effect": see our Plate LIII showing bowing in the femur of the gorilla with absence of the pilaster. To these arguments we might rejoin in the first case that because in a diseased bone bowing may be due to mechanical causes, it does not follow that such is the whole source or even the source at all of it in normal bones. In the second case Antony and Rivet themselves endeavour to explain the considerable curvature in the gorilla and chimpanzee with the small pilastric development by their arboreal progression by aid of their upper limbs. Their prevalent position on trees with bent knees requires the adductor muscle to reach the posterior face of the femur and to keep clear of it; hence the posterior face is scooped out and there is a compensatory frontal development[3]. It would thus seem that absence of the pilaster in the apes and presence

[1] Bumüller (Bibl. 81, S. 44) states that he found L. (128) 6° 40′ and R. (127) 8° 15′ for his *Krümmungswinkel.* We do not, however, accept this measure of bowing and Bumüller is quite probably recording a characteristic wholly different from ours.

[2] Bibl. 57.

[3] Bibl. 97, pp. 258—9.

in man both lead to a "compensatory effect" in bowing. Whatever may be said of the argument, it is clear that the first question we must answer is to what intensity is the index of bowing associated with the pilaster? We must correlate the index of bowing and the pilastric index. Antony and Rivet do not write with knowledge of the modern theory of correlation, but they group their limited material into three classes of large, moderate and small character, pilastric index, say, average these classes and place against each group its mean radius of curvature. The danger of this method is considerable, not only in that it fails to give us a quantitative measure of the correlationship, but that in such inadequate material a flat bone immensely modifies the mean of any class. The following is their table:

	♂			♀		
Group	No.	Pilastric Index	Radius *R.*	No.	Pilastric Index	Radius *R.*
First	20	118·3	96·3	11	115·6	106·0
Second ...	19	111·5	110·4	12	108·0	110·9
Third ...	14	105·0	126·1	14	103·2	118·3

The table shows that where the curvature $\left(\frac{1}{R}\right)$ is greatest the pilastric index is greatest. But the result is based on the by no means justified exclusion of six male and three female bones.

Taken from Antony and Rivet's data for the apes and our data for man we have the following comparative table[1]:

Species	No.	Curvature	Pilastric Index	Platymeric Index	Cervical Index	Angle of Neck and Shaft	Obliquity	Torsion
Pithecanthropus	1	·0000(?)	109·1	[94·0?]	?	125°·0	12°·0	15°·0
Gibbon ...	15	·0054	97·0	91·2(?)	80·9	125°·8	1°·96	8°·0
Orang	4	·0069	78·8	71·8	71·9	138°·0	1°·8	[−5°·65]
Man	476	·0096	104·5	85·2	75·7	130°·9	10°·14	13°·2
Woman ...	361	·0097	101·7	82·9	77·0	129°·8	10°·58	16°·1
Chimpanzee ...	19	·0129	85·9	84·2	84·1	127°·1	2°·12	3°·7
Gorilla	26	·0139	76·8	82·1	74·8	122°·5	2°·75	0°·9(?)

There appears to be no correlation interracially between any of these characters and the curvature. All that comes out of such a table is (i) further illustration of the "scission of the primates" and (ii) the close accordance of the Trinil femur with

[1] The means for somewhat larger numbers of ape femora for certain of the characters are given by Rodriguez (Bibl. 101) without essential modifications, *i.e.*

Species	No.	Pilastric Index	Platymeric Index	Angle of Neck and Shaft	Torsion
Orang	5	78·47	71·24	136°·8	−3°·9
Chimpanzee ...	24	84·62	82·76	125°·6	+5°·4
Gibbon	23	97·07	82·83*	124°·2	+8°·4
Gorilla	41	75·38	81·04	121°·6	+7°·7*

* These characters show the most divergence from the table above. Our values are 83·7 and 7°·5 respectively, substantially agreeing with Rodriguez.

the human femur. So close is this that we ventured to hesitate before accepting its radius of curvature as "circa ∞," and found it to be ·0076, quite human[1]. Intraracially we have now to investigate what our own data show for the pilastric index.

Correlation of Primary Index of Bowing and Pilastric Index.

♂		♀	
R.	L.	R.	L.
·257 ± ·041	·223 ± ·041	·229 ± ·049	·192 ± ·048

It is clear therefore that intraracially the pilastric index is significantly, although only moderately, correlated with the bowing. The more the pilaster is developed the greater the bowing. But the association is hardly so marked that we can look upon the one as a primary source of the other. The bowing appears to be related in some secondary manner to the pilastric development. It would be risky to hold that one is the outcome of the other[2]. Turning from Manouvrier's theory of "compensating effect" we may now investigate certain correlations which bear on the theory of mechanical influence. Antony and Rivet found no relationship between the absolute size of the bone and its curvature[3]. We have considered the maximum length of the femur and the primary index of bowing, but we feared spurious correlation, the length including the diaphysial chord as part of itself. Accordingly we took the bicondylar width as a good measure of the size of the bone, and again the capito-collar length as to some extent measuring the leverage.

[1] See the third footnote p. 279 above.

[2] Bumüller (Bibl. 81, S. 38) gives the following table which he says is based on 245 femora (? sides and sexes pooled):

Pilastric Index	Below 90	90—100	100—110	110—120	Over 120
Mean Angle of Curvature	With Pilaster 5° 40′ / Without Pilaster 7° } 6°	7° / 7° } 7°	7° 30′	9°	9° 30′

We are not, however, able to accept Bumüller's *Krümmungswinkel* as a scientific measure of curvature. He deduces from the above results that the pilaster is not the primary source of bowing. Bumüller (*loc. cit.* S. 41) also investigates the association in about 50 femora (? side and sex) of his angle of curvature and the index 100 platymeric/pilastric antero-posterior diameter. The data are too few to provide definite results.

[3] They give the following table, and although the differences of the groups are just as marked as in their table of the pilastric index, they do not consider them of any value because the two variates show no systematic changes; they even suggest that the irregularities may be due to erroneous sexing.

	♂			♀		
	No.	Oblique Length	Radius *R.*	No.	Oblique Length	Radius *R.*
1st Group ...	15	427·5	113·9	11	391·0	102·6
2nd Group ..	14	411·3	113·9	12	369·5	117·4
3rd Group ...	17	395·9	103·9	10	356·8	104·8

None of these indicate any persistent relationship at all between the size of bone and the bowing, as the following table indicates:

Correlation of Bowing with Absolute Femoral Lengths.

Index of Bowing with	♂		♀	
	R.+L.		R.+L.	
Maximum Length ...	−·041 ± ·032		−·019 ± ·037	
	R.	L.	R.	L.
Bicondylar Width ...	−·068 ± ·055	−·144 ± ·052	−·248 ± ·064	+·017 ± ·064
Capito-collar Length ...	−·136 ± ·044	+·066 ± ·045	+·009 ± ·053	+·023 ± ·050

It may be considered that what we need is not absolute size, but some measure of the slenderness of the bone to correlate with the bowing—a long slender bone would be more subject to mechanical effect. Accordingly we correlated the index of robusticity, *i.e.* 100 sum of pilastric diameters/oblique length with the bowing and found the following values:

Correlation of Indices of Bowing and Robusticity.

♂, R.	♂, L.	♀, R.	♀, L.
+·368 ± ·041	+·159 ± ·045	+·262 ± ·051	+·176 ± ·052

These values are significant if not very large, the right bones showing higher correlation than the left. But they tell exactly against the mechanical influence theory—the more robust bones being the more bowed. This is probably only another path to the old conclusion that bowed bones tend to have a larger pilastric antero-posterior diameter[1]. Beyond these correlations we have calculated a number of others as a means of testing the conclusions reached by Antony and Rivet on our wider material by more adequate statistical methods. We give first Antony and Rivet's conclusion and then follow it with our own.

A.+R.'s statement: *Curvature has no relation to the Platymeric Index.*

Our material	♂, R.	♂, L.	♀, R.	♀, L.
Index of Bowing and Platymeric Index	+·061 ± ·044	+·097 ± ·043	−·069 ± ·051	+·009 ± ·049

The correlations are non-significant and not always of same sign. Antony and Rivet's conclusion is confirmed. We have investigated the Popliteal Index also. Thus:

Our material	♂, R.	♂, L.	♀, R.	♀, L.
Index of Bowing and Popliteal Index	−·097 ± ·045	−·004 ± ·044	+·044 ± ·052	−·094 ± ·049

[1] Antony and Rivet (Bibl. 97, p. 255) conclude that the bowing is slightly more accentuated in the robuster bones, but we do not consider this result justified by their data. Their classes show very irregular values of R, and in the case of the female bones the least robust show the greatest curvature.

The correlations are non-significant. Thus the flattening of the bone beyond our diaphysial chord seems to have no influence on the bowing.

A. + R.'s statement: *Curvature is least where the obliquity is greatest.*

Our material	♂, R.	♂, L.	♀, R.	♀, L.
Obliquity and Index of Bowing ...	− ·004 ± ·046	+ ·056 ± ·044	− ·179 ± ·052	+ ·107 ± ·051

The correlations are scarcely significant and not even of the same sign. We think Antony and Rivet's conclusion cannot be confirmed.

A. + R.'s statement: *Curvature has no relation to the shape of the neck.*

We have correlated the Index of neck = 100 horizontal diameter of the neck/vertical diameter of the neck with the index of bowing, and find:

Our material	♂, R. + L.	♀, R. + L.
Primary Index of Neck and Index of Bowing	− ·112 ± ·031	+ ·003 ± ·037

There is no relationship in the case of the female bones; there is a possibly just significant relationship but one of no importance in the case of the male bones. What relation there is, however, indicates that the rounder the neck the less the bowing.

A. + R.'s statement: *The smaller the cervical angle the greater the curvature.*

Our material	♂, R. + L.	♀, R. + L.
Angle of Neck and Shaft and Index of Bowing	− ·054 ± ·031	− ·081 ± ·036

Thus the sign of Antony and Rivet's correlation is confirmed, but the values can scarcely be called significant relative to their probable errors. We do not think that the angle of neck and shaft has really any sensible "mechanical effect" on the bowing. Lastly we take the torsion of the *shaft, i.e.* not that of the femur, as a whole, and find:

Our material	♂, R.	♂, L.	♀, R.	♀, L.
Torsion of Shaft and Index of Bowing	− ·143 ± ·045	− ·195 ± ·044	− ·078 ± ·053	− ·091 ± ·052

Our signs are consistently negative, although only the male values can be considered definitely significant. We conclude that the more torsion of the shaft the

less it is bowed. This is definitely opposed to Antony and Rivet's conclusion that the larger the torsion the greater the curvature is, but they are using torsion for the whole femur, including the retorsion of head and neck. It seemed to us better to use the torsion of the shaft only as we were considering the bowing of the shaft. We have, however, considered the correlation of the torsion for the whole femur with the primary index of bowing. We find:

Our material	♂, R.	♂, L.	♀, R.	♀, L.
Correlation of Bowing and Torsion ...	$-\cdot023 \pm \cdot047$	$-\cdot106 \pm \cdot046$	$-\cdot052 \pm \cdot056$	$-\cdot037 \pm \cdot054$

These are all *less* than the correlations of torsion of shaft with bowing; they are, however, all of the same *negative* sign, although individually insignificant. We cannot therefore confirm Antony and Rivet's view that the larger the torsion the greater the curvature; it certainly is not true for our index of bowing. On the contrary we think it probable that torsion is a secondary means of attaining the same end as bowing.

To sum up: There are no close correlations between the bowing of the femur and any of its component parts or characters upon which we might suppose the "mechanical effect" to depend. We can find no evidence therefore for the theory of mechanical influence being the source of the normal or physiological bowing of the femur—the source of bowing in diseased femora is not necessarily the source in the normal bone. There is a definite, if small, correlation between torsion and bowing, the more torsion the less bowing. This is a clue which might prove of some interest; the effect of torsion would be to rotate slightly the platymeric end of the shaft so as to bring its transverse diameter more nearly into the plane of bending and so strengthen the shaft considered as a strut. The retorsion of the neck and head would result as a readjustment of the torsion of the shaft arising as a strengthening factor against bending. As one serves to some extent the purpose of the other, it is not so surprising to find bowing and torsion negatively correlated. At the same time the torsion would tend merely from geometrical considerations to cause the bone to present a flatter or less bowed anterior surface. It would thus be seen that the development of the pilaster with bowing and the extensive torsion of the shaft in the case of the human femur may really be due to one and the same physiological necessity—and form two fundamental methods of strengthening the femur to carry its vertical load by increasing the diameter in the plane of buckling. From this standpoint bowing and pilastric development are not effect and cause; they are not due to a compensatory principle, but are both physiological endeavours to obtain a big diameter in the weakest buckling plane. In precisely the same way as the Greeks had learnt to slightly bulge their columns to give increased strength, so the bowing is a bulge to strengthen the cross-sections in proportion to their respective weakness. In fact if we could solve the elastic problem of bending in a column so complicated

in form, and with so numerous force applications as in the muscular attachments, as the femur we might well find that the secondary index of bowing was determined by the elastic conditions of the problem itself on the plan of the "solid of equal resistance." We conclude then from the two correlations with bowing that are really of importance, that with the pilastric index (including the index of robusticity) and that with the torsion of the shaft, that bowing is not due to mechanical influences during growth, but is a physiological development (arising in the course of evolution by selection) tending to produce a column of greater and more uniform strength for the purpose of carrying a vertical load. In coming to this conclusion we do not deny that a diseased bone may bow owing to mechanical influence, and that the compression on the posterior face may lead to a pilastric development—rather the inverse of Manouvrier's compensation principle—but we gravely doubt whether such extreme cases as may be seen in our Plates XXXIII—XXXV can be used as an argument as to what happens in healthy bones developing normally. Even if such were the immediate source of growth to the desirable form—a moderately bowed bone with a considerable pilaster—it does not follow that the ultimate reason for this form is not the "solid of equal resistance" conception; it would merely indicate that the growth factors had been adapted to the required end[1].

VIII. *On the Curvature of the Popliteal Area.*

We have already discussed this point at some length when dealing with the measurement of the popliteal index. The main point from which the importance of a determination of the curvature arises is that the sign of the curvature has been taken as a character differentiating man from the anthropoid apes, and Dubois[2] emphasises the convexity of the Trinil femur as a factor which makes it essentially apelike amid very human general features. We tested the flatness[3] at the popliteal section (taken at 4 cms. in man: see our p. 9) and at $\frac{1}{10}$ the diaphysial length in the apes. We examined 23 femora of the orang-utan; the femur was sensibly convex in 19 cases, convex although approaching to flat in two and flat in two only; there was no case of concavity. We examined 20 femora of the chimpanzee; of these 17 were sensibly convex, two were, we hold, convex but difficult of determination, and one was flat; none were concave. We examined 16 femora of the gorilla; of these

[1] We have not investigated the transverse as distinct from the sagittal bowing of our bones, as it appeared to us almost impossible to measure it adequately. The only statistical data we know of on this point are those due to Bumüller (Bibl. 81, S. 44) who states that in 246 femora he found lateral transverse bowing in 27 cases and mesial transverse bowing in 20 cases. He does not, however, state how he appreciated the presence and absence of this bowing. His discussion of the subject is slender and not convincing.

[2] In his paper of 1896 Dubois again emphasises the rounded popliteal surface as the only difference between the Trinil and a human femur. He says that the "Art Wulst" which occurs (exactly as in our L. S. 46!) appears also in the gibbon and suggests that when it does occur, as rarely in man, it may well be associated with "eine affenähnliche Muskelvarietät." Bibl. 70 *bis*, S. 19.

[3] As a rule the convexity or concavity can be judged at once by sight or touch. In nearly flat cases it is best to press a thin plane strip of metal against the surface and see which way its terminals move.

four were sensibly convex; four were slightly but not markedly convex; two were actually convex but looked flat to the eye; two were actually flat; two were just on the concave side of flatness, and the remaining two very slightly but appreciably concave. Thus while concavity does not occur in the orang and chimpanzee femora examined by us, we found it in a not marked form in 25 °/₀ of the gorilla femora. Turning to the human femora we determined the curvature in the London series of nearly 800 cases[1] and found:

Curvature Percentages.

	Convex	Flat	Concave
Male Right	51·5 °/₀	13·3 °/₀	35·2 °/₀
Male Left	48·8 °/₀	23·8 °/₀	27·4 °/₀
Female Right ...	31·7 °/₀	16·1 °/₀	52·2 °/₀
Female Left ...	34·5 °/₀	22·2 °/₀	43·3 °/₀

Now this table appears to us somewhat noteworthy: the general impression that the popliteal surface in man is concave is not confirmed. Among males about 50 °/₀ have their femora convex, only a little over 30 °/₀ are concave; among females the reverse numbers roughly hold, about 50 °/₀ are concave and a little over 30 °/₀ are convex. It is not possible to speak of concavity as the rule in the human femur. Further concavity seems a secondary sexual character, being much more marked in the female, while there is some evidence to show that the left bone is in respect of concavity "more male than the right." Those who believe that "muscle moulds form" will see no doubt in the more apelike popliteal surface of the male some product of greater musculature. All we should suggest would be that the more apelike form of the male is certainly associated with greater muscular development.

We are now in a position to consider how far the popliteal indices can achieve the principal purposes for which they were designed. It will be remembered that they were introduced by Manouvrier as a means of quantitatively comparing the popliteal area of the Trinil femur with those of the apes, of palaeolithic man and of recent man. From this standpoint considerable stress has been laid on the relative magnitude of the direct[2] and the oblique antero-posterior popliteal diameters, the *mp* and *mn* of our Diagrams *C* (Plate II) and *E* (Plate III). We have already shown that the relative magnitude of *mp* and *mn* in individual cases will form no true measure of the convexity and concavity of the popliteal surface (see our p. 15), but we have yet to investigate whether in the mass of the population there is any relation between concavity and our secondary popliteal index, *i.e.* 100 × ratio of direct to oblique antero-posterior diameter. We have formed four correlation tables connecting this secondary popliteal index with the popliteal curvature.

[1] Bumüller (Bibl. 81, S. 65) gives for 193 Bavarian femora: convex, 29·0 °/₀; flat, 48·2 °/₀; concave, 22·8 °/₀. He has clearly put far more into the flat category than a mathematician would do, and accordingly we do not think the numbers point necessarily to a racial difference.

[2] The term "direct" is convenient but not wholly adequate; *mp* is often itself very oblique to the sagittal plane of the femur.

Correlation of Index of Popliteal Skewness with Popliteal Curvature.

Value of Index of Popliteal Skewness.

Sex and Side	Curvature	78*	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	Totals	Means of Arrays
Male Right	Concave	—	—	—	1	-	1	5	1	6	8	8	5	14	5	9	7	5	1	3	—	2	81	90·24
	Flat	—	—	—	—	—	1	—	—	3	3	4	—	3	3	1	3	1	1	7	—	—	30	91·42
	Convex	—	—	1	—	1	1	3	5	6	3	5	14	11	17	8	12	6	9	9	—	3	114	91·25
	Totals	0	0	1	1	1	3	8	6	15	14	17	19	28	25	18	22	12	11	19	—	5	225	—
Male Left	Concave	1	1	—	—	1	—	1	5	3	5	14	3	5	6	5	7	2	2	1	1	—	63	89·62
	Flat	—	1	—	1	1	—	—	1	3	1	5	6	4	6	8	6	6	4	2	1	—	56	90·96
	Convex	—	—	—	1	1	1	3	3	2	8	9	7	10	17	8	12	8	8	6	2	7	113	93·35
	Totals	1	2	0	2	3	1	4	9	8	14	28	16	19	29	21	25	16	14	9	4	7	232	—
Female Right	Concave	—	—	—	—	1	2	6	7	14	5	11	8	12	7	7	2	4	1	4	1	—	92	89·20
	Flat	—	—	1	—	1	1	—	1	—	1	2	2	3	4	2	3	2	2	3	—	—	28	90·95
	Convex	—	—	—	—	1	2	—	1	4	3	5	1	7	3	4	6	10	1	5	1	2	56	91·59
	Totals	0	0	1	0	3	5	6	9	18	9	18	11	22	14	13	11	16	4	12	2	2	176	—
Female Left	Concave	—	—	—	—	1	—	3	5	4	13	6	6	10	4	13	3	9	1	—	—	2	80	90·10
	Flat	—	—	1	2	1	—	3	1	2	1	1	2	4	4	7	1	3	2	2	2	2	41	90·72
	Convex	—	—	2	—	—	—	1	—	2	1	7	6	5	3	11	1	8	4	7	—	4	62	92·01
	Totals	0	0	3	2	2	0	7	6	8	15	14	14	19	11	31	5	20	7	9	2	8	183	—

* 78— stands for group from 77·95 to 78·95, centre at 78·45; the indices were tabled to one decimal place only.

Examining the means of the arrays it will be seen that with the not very marked exception of male right the secondary mean index increases from concave to flat and again from flat to convex. But the increases though quite sensible are never very great, two to three points at most. Thus the correlation between the index of popliteal skewness and the curvature of the popliteal surface cannot be more than very moderate, so small in fact that as the tables themselves show it would not be possible to predict from the index whether the bone was convex or not. To illustrate this point we have formed two biserial tables for ♂, R. + L. and ♀, R. + L., the divisions being concave and not concave (*i.e.* flat or convex).

Value of Index of Popliteal Skewness.

Sex	Curvature	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	Totals
♂ R.+L.	Concave	1	1	—	1	1	1	6	6	9	13	22	8	19	11	14	14	7	3	4	1	2	144
	Not Concave	—	1	1	2	3	3	6	9	14	15	23	27	28	43	25	33	21	22	24	3	10	313
	Totals	1	2	1	3	4	4	12	15	23	28	45	35	47	54	39	47	28	25	28	4	12	457
♀ R.+L.	Concave	—	—	—	—	2	2	9	12	18	18	17	14	22	11	20	5	13	2	4	1	2	172
	Not Concave	—	—	4	2	3	3	4	3	8	6	15	11	19	14	24	11	23	9	17	3	8	187
	Totals	0	0	4	2	5	5	13	15	26	24	32	25	41	25	44	16	36	11	21	4	10	359

The correlations found by the biserial method are:

♂ (R. + L.), $r = +\cdot2300 \pm \cdot0396$; ♀ (R. + L.), $r = +\cdot2920 \pm \cdot0416$.

These are quite significant, but only moderate in intensity. We conclude therefore that the direct and oblique antero-posterior popliteal diameters are unlikely by their relative size to throw much light on popliteal curvature.

We next proceeded to consider how far the primary popliteal index, *i.e.* 100 × ratio of antero-posterior popliteal diameter to popliteal width, is related to popliteal curvature.

Correlation of Primary Popliteal Index and Popliteal Curvature.

Value of Primary Popliteal Index.

Sex and Side	Curvature	49·5 — 52·5	52·5 — 55·5	55·5 — 58·5	58·5 — 61·5	61·5 — 64·5	64·5 — 67·5	67·5 — 70·5	70·5 — 73·5	73·5 — 76·5	76·5 — 79·5	79·5 — 82·5	82·5 — 85·5	85·5 — 88·5	88·5 — 91·5	91·5 — 94·5	Totals	Means of Arrays
Male Right	Concave	1	—	3	9·5	6·5	18	19	10	8	2·5	2	0·5	—	—	—	80	67·78
	Flat	—	—	—	1·5	1·5	6	8	4	2	3	3	1	—	—	—	30	71·05
	Convex	—	—	—	1	8·5	13·5	24	14	20	18·5	9·5	1·5	0·5	2	—	113	72·68
	Totals	1	0	3	12	16·5	37·5	51	28	30	24	14·5	3	0·5	2	0	223	—
Male Left	Concave	1	1	3	5·5	8·5	14·5	11·5	8	2	3	2	2·5	0·5	—	—	63	67·74
	Flat	—	—	1	3	5	9	8·5	10·5	12·5	3·5	2	1	—	—	—	56	70·45
	Convex	—	1	—	1	5	9	19	21·5	21	22·5	9	3	1	—	—	113	73·27
	Totals	1	2	4	9·5	18·5	32·5	39	40	35·5	29	13	6·5	1·5	0	0	232	—
Female Right	Concave	—	—	8	13	21	21·5	16·5	7·5	3·5	1	—	1	—	—	—	93	65·39
	Flat	—	1	—	2	7	6	5	5	1	1	—	—	—	—	—	28	66·75
	Convex	—	—	2	1	8	7·5	12·5	9	9·5	4·5	—	1	1	—	—	56	69·96
	Totals	0	1	10	16	36	35	34	21·5	14	6·5	0	2	1	0	0	177	—
Female Left	Concave	—	—	3	8	17	22	14	9·5	3·5	—	2·5	0·5	—	—	—	80	66·64
	Flat	—	—	—	6	5	9	5	2	10	2	2	—	—	—	—	41	68·93
	Convex	—	—	—	2	3	11	11	14·5	9	5·5	5	—	—	—	1	62	71·61
	Totals	0	0	3	16	25	42	30	26	22·5	7·5	9·5	0·5	0	0	1	183	—

Here without exception there is a continuous and steady rise in the value of the mean primary popliteal index as we pass from concave to flat and flat to convex popliteal areas. Combining as before right and left bones to form two biserial tables we have :

Value of Primary Popliteal Index.

Sex	Curvature	49·5 — 52·5	52·5 — 55·5	55·5 — 58·5	58·5 — 61·5	61·5 — 64·5	64·5 — 67·5	67·5 — 70·5	70·5 — 73·5	73·5 — 76·5	76·5 — 79·5	79·5 — 82·5	82·5 — 85·5	85·5 — 88·5	88·5 — 91·5	91·5 — 94·5	Totals
♂ R. + L.	Concave	2	1	6	15	15	32·5	30·5	18	10	5·5	4	3	0·5	—	—	143
	Not Concave	—	1	1	6·5	20	37·5	59·5	50	55·5	47·5	23·5	6·5	1·5	2	—	312
	Totals	2	2	7	21·5	35	70	90	68	65·5	53	27·5	9·5	2	2	0	455
♀ R. + L.	Concave	—	—	11	21	38	43·5	30·5	17	7	1	2·5	1·5	—	—	—	173
	Not Concave	—	1	2	11	23	33·5	33·5	30·5	29·5	13	7	1	1	0	1	187
	Totals	0	1	13	32	61	77	64	47·5	36·5	14	9·5	2·5	1	0	0	360

The biserial correlations are :

$$♂,\ r = +\cdot4358 \pm \cdot0354\ ;\quad ♀,\ r = +\cdot4059 \pm \cdot0387.$$

There is thus a quite significant and substantial correlation between curvature of the

popliteal surface and the customary popliteal index[1]. This correlation is nearly double that of the secondary popliteal index; or, *the popliteal index is a very much better guide to the pithecoid character of the popliteal surface than the relative dimensions of the direct and oblique antero-posterior popliteal diameters.*

Assuming, which is fairly accurate, that marked convexity of the popliteal surface is more ape-like than man-like, in the first place we may consider an index which marks in a certain manner the gracility of the human femur, namely the second transverse index of the shaft or the ratio of 100 pilastric transverse diameter to popliteal width. This index will be nearer 100 in the ape than in man, although in individual human cases it can approach this value. We should therefore anticipate that concavity may be associated with a low value of this gracility index. The tables are given below. An inspection of the means of the arrays shows in the case of both right and left male bones increase of the gracility index (decreased gracility) as we pass from concave to flat and flat to convex bones; the total increase, however, is less than two points. The flat bones are anomalous in the case of the female femora, but in both cases of right and left, the concave bones are more gracile than the convex[2].

CORRELATION OF INDEX OF DISTAL GRACILITY AND POPLITEAL CURVATURE.

Value of Index of Gracility.

Sex and Side	Curvature	52*	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	Totals	Means of Arrays
Male Right	Concave	—	—	—	1	6	12	8	7	10	9	7	10	5	3	3	—	—	—	—	—	1	—	82	69·97
	Flat	—	—	—	—	3	2	3	3	2	7	4	3	1	—	—	—	1	1	—	—	1	—	31	70·89
	Convex	—	—	—	4	4	7	10	10	9	13	17	9	16	4	2	2	4	1	1	—	—	—	113	71·57
	Totals	0	0	0	5	13	21	21	20	21	29	28	22	22	7	5	2	5	2	1	0	2	0	226	—
Male Left	Concave	1	—	—	2	1	6	5	8	5	9	9	7	6	1	1	1	—	2	—	—	—	—	64	70·51
	Flat	—	2	—	—	2	4	6	4	5	8	5	12	8	3	2	—	—	1	—	—	—	—	62	71·27
	Convex	—	—	1	2	4	8	5	7	15	15	15	4	9	11	2	4	3	1	—	1	—	—	107	71·92
	Totals	1	2	1	4	7	18	16	19	25	32	29	23	23	15	5	5	3	4	0	1	0	0	233	—
Female Right	Concave	2	—	—	3	2	11	9	11	8	15	11	10	6	1	1	1	—	1	1	—	—	—	93	69·53
	Flat	—	—	—	1	1	2	4	3	5	4	4	2	1	—	1	—	—	—	—	—	—	—	28	69·09
	Convex	—	—	1	—	1	8	7	5	4	8	10	2	4	1	1	2	1	—	—	1	—	—	56	70·41
	Totals	2	0	1	4	4	21	20	19	17	27	25	14	11	2	3	3	1	1	1	1	0	0	177	—
Female Left	Concave	—	1	—	1	3	5	9	7	8	14	8	7	9	1	4	1	1	1	—	—	—	—	80	70·85
	Flat	—	—	—	1	1	—	6	4	2	4	9	4	1	2	1	2	1	1	—	1	—	1	41	72·13
	Convex	—	—	—	—	3	4	2	10	6	9	3	5	6	4	4	1	1	—	1	—	—	1	60	71·70
	Totals	0	1	0	2	7	9	17	21	16	27	20	16	16	7	9	4	3	2	1	1	0	2	181	—

* 52— connotes 51·95—52·95.

[1] Bumüller (Bibl. 81, S. 65) gives results for 53 Bavarian bones only:

Mean Popliteal Index: Convex (18), 82·2; flat (20), 75·4; concave (15), 80·1,

and argues from this that "flat" is not intermediate between convex and concave. Our results on far ampler material show, however, an orderly sequence and it appears unnecessary to discuss his explanations of a result based on such slender numbers.

[2] Bumüller (Bibl. 81, S. 66) gives the means of what he terms the "transversal index" for a few convex, concave and flat bones. This index is the inverse of our Index of Distal Gracility. In our notation he obtains: Convex, 68·8; flat, 66·7; concave, 66·3.

These results are in the same sense as ours indicating increased gracility with concavity.

Using biserial tables, the two categories being concave and not concave, we find:

$$\delta\ (\text{R.} + \text{L.}),\ r = +\cdot1413 \pm \cdot0415\ ;\quad \varphi\ (\text{R.} + \text{L.}),\ r = +\cdot1148 \pm \cdot0442.$$

Accordingly judging from the second transverse shaft index gracility is significantly, but only very slightly, associated with a concave popliteal surface.

The following are the biserial tables deduced from the above adding together right and left members:

Value of Index of Distal Gracility.

Sex	Curvature	52*	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	Totals
		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
♂ R.+L.	Concave	1	—	—	3	7	18	13	15	15	18	16	17	11	4	4	1	—	2	—	—	1	—	146
	Not Concave	—	2	1	6	13	21	24	24	31	43	41	28	34	18	6	6	8	4	1	1	1	—	313
	Totals	1	2	1	9	20	39	37	39	46	61	57	45	45	22	10	7	8	6	1	1	2	—	459
♀ R.+L.	Concave	2	1	—	4	5	16	18	18	16	29	19	17	15	2	5	2	1	2	1	—	—	—	173
	Not Concave	—	—	1	2	6	14	19	22	17	25	26	13	12	7	7	5	3	1	1	2	—	2	185
	Totals	2	1	1	6	11	30	37	40	33	54	45	30	27	9	12	7	4	3	2	2	—	2	358

* 52— connotes 51·95—53·95.

Two further indices bearing on the popliteal surface have also been correlated by us with the popliteal curvature. The first of these is the soffit index or 100 × ratio of popliteal width to bicondylar width. It has been suggested that the sudden narrowing in above the condyles may be a differential mark between the Neanderthal type and *Pithecanthropus*: see Fig. 2, p. 10 above. Somewhat akin to this point is the "Eifel Tower" form or pyramidal structure of the lower third of the femur in man. We have endeavoured to measure this also so-called "trumpet" form by our second, the pyramidal index, *i.e.* 100 × ratio of popliteal width to popliteal length. The tables on the following page were obtained for these two correlations.

The results for the soffit index and the curvature are singularly consistent; there is a quite definite if not very large correlation between concavity and a high value of the index. The means all run one way, and the convex or more apelike femora have a narrower popliteal surface relative to the bicondylar width. The *Pithecanthropus* soffit index is 46·2 which is well within the range of modern man (although the mean of the latter is about 50·00[1]), and is hardly differentiated from the Neanderthal femur at 45·3. The order of means is:

	♂ (R.+L.)	♀ (R.+L.)
Concave	51·07	51·60
Flat	50·23	51·30
Convex	49·67	49·07
Correlation of Concavity and high Index	+·2450 ± ·0476	+·2579 ± ·0562

[1] If we take the values of the indices for *Pithecanthropus* and Neanderthal from Klaatsch's contour drawing (p. 10) we have 50·96 and 36·59! His "modern man" seems to be unfortunately selected; it gives an index of 43·18, which according to our experience is far from the type value for the human femur. Hepburn's data give 50·14 for British, in excellent agreement with ours; 43 is a value of the soffit index

Correlation of Curvature and Soffit Index.

Soffit Index.

Sex	Curvature	37*	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52
		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
♂ R. + L.	Concave	—	1	1	—	1	1	3	2	3	9	5	7	8	9	7	12
	Flat	—	—	—	—	—	2	1	4	5	6	2	3	3	8	9	2
	Convex	1	—	—	2	1	4	4	4	15	11	15	15	11	17	10	6
	Totals	1	1	1	2	2	7	8	10	23	26	22	25	22	34	26	20
♀ R. + L.	Concave	—	—	—	—	—	1	1	2	1	7	6	4	7	12	10	12
	Flat	—	—	1	—	—	2	—	—	1	1	5	3	2	5	3	4
	Convex	1	—	—	1	—	1	1	5	4	8	5	4	1	13	8	4
	Totals	1	0	1	1	0	4	2	7	6	16	16	11	10	30	21	20

Sex	Curvature	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	Totals
		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
♂ R. + L.	Concave	8	7	4	5	2	4	1	2	—	—	—	—	—	—	1	103
	Flat	7	5	3	2	1	—	1	—	—	—	—	—	—	—	—	64
	Convex	7	4	6	3	—	1	1	—	—	—	—	—	—	—	—	138
	Totals	22	16	13	10	3	5	3	2	0	0	0	0	0	0	1	305
♀ R. + L.	Concave	13	9	3	5	2	2	—	—	1	1	—	—	—	—	—	99
	Flat	—	4	3	2	—	2	—	—	1	1	—	—	—	—	—	40
	Convex	4	2	1	2	—	—	—	—	—	—	—	—	—	—	—	65
	Totals	17	15	7	9	2	4	0	0	2	2	0	0	0	0	0	204

* 37— stands for 36·95 to 37·95.

It will be seen that the association of concavity with a high index in the individuals of the race, is in accordance with an evolution from Neanderthal type to the modern femur. It is in the same accordance with the difference between *Pithecanthropus* and the modern femur. But we have to remark here that the soffit index for the Trinil femur is really not accurately known, and the question whether the "Art Wulst" is typical or anomalous has not yet been really settled.

We now turn to the pyramidal popliteal index, of which the correlation with the curvature is provided in the following table.

corresponding to Andamans, Negroes or Australian natives. Measured on Dubois' photographs we find the index for *Pithecanthropus* 46·2 rather than the 51·0 of Klaatsch's diagram, and the cast of the Neanderthal femur gives the value 45·3, close to 45·8 which we find as the Neanderthal type mean. Exact measurements of the Trinil femur are here as usual urgently necessary.

CORRELATION OF CURVATURE WITH PYRAMIDAL POPLITEAL INDEX.

Pyramidal Popliteal Index.

Sex	Curvature	21*	22	23	24	25	26	27	28	29	30	31	32	33	34
		—	—	—	—	—	—	—	—	—	—	—	—	—	—
♂ R. + L.	Concave	—	—	—	1	6	3	6	9	10	9	9	17	12	13
	Flat	—	—	1	—	—	2	8	6	7	7	6	12	6	7
	Convex	1	—	2	2	8	8	9	22	12	17	24	19	16	15
	Totals	1	0	3	3	14	13	23	37	29	33	39	48	34	35
♀ R. + L.	Concave	—	1	1	1	7	8	12	6	21	14	14	13	10	15
	Flat	1	1	—	—	2	2	1	6	9	6	8	3	2	6
	Convex	1	—	—	3	1	3	3	9	5	15	7	12	11	12
	Totals	2	2	1	4	10	13	16	21	35	35	29	28	23	33

Sex	Curvature	35	36	37	38	39	40	41	42	43	44	45	46	47	48	Totals
		—	—	—	—	—	—	—	—	—	—	—	—	—	—	
♂ R. + L.	Concave	13	7	6	8	4	2	1	3	1	1	2	—	1	—	144
	Flat	5	2	6	1	4	2	2	1	—	—	—	—	—	1	86
	Convex	9	15	5	15	9	7	3	2	1	1	1	—	—	—	223
	Totals	27	24	17	24	17	11	6	6	2	2	3	0	1	1	453
♀ R. + L.	Concave	10	7	4	5	10	2	3	1	4	—	1	—	—	—	170
	Flat	4	4	—	4	1	4	1	2	1	—	1	—	—	—	69
	Convex	4	5	2	8	5	3	4	—	1	—	—	—	—	1	115
	Totals	18	16	6	17	16	9	8	3	6	0	2	0	0	1	354

* 21— signifies 20·95 to 21·95.

The correlations as in the previous tables were found by the biserial method dividing into concave and not concave. The following values resulted:

Values of Means of Pyramidal Indices for Arrays.

	♂ (R. + L.)	♀ (R. + L.)
Concave	33·42	32·54
Flat	32·93	32·96
Convex	32·78	33·18
Correlation of Curvature and high Index	+ ·0794 ± ·0411	− ·0744 ± ·0448

The means run smoothly, but in opposite senses for the two sexes. Hence there may be significant sexual difference in the relationship of curvature and pyramidal index, a long trumpet shape being associated with convexity in the male and concavity in the female. The correlations, however, are so small that there is possibly no relationship whatever between these characters.

Lastly we thought it worth investigating whether the curvature of the popliteal surface was connected with (i) a marked feature of man's upward progress and (ii) a

human anomaly which characterises his relation to lower forms. As our first variate we selected the band-radial index ; as our second the presence of the third trochanter. The great difference in tension of femoro-fibular ligament, when the upper and lower members of the leg are straight or bent, has been attributed largely to the difference between the vertical and horizontal " band-radii " of the external condyle. The area of attachment of this ligament can be clearly seen in Diagram E (Plate III) and the general excess of the vertical over the horizontal radius is indicated, although it is difficult of exact measurement. The upright position of man has been closely associated with the band-radial index = 100 vertical band-radius/horizontal band-radius. We should accordingly consider, if man's upright position be associated with the band-radial index and convexity with the ape, that convexity would be correlated negatively and substantially with the magnitude of the band-radial index. It will be seen by examining the

Correlation of Band-radial Index and Popliteal Curvature[1].

Value of Band-radial Index.

Sex and Side	Curvature	81*	84	87	90	93	96	99	102	105	108	111	114	117	120	123	126	129	132	135	138	141	144	Totals	Means of Arrays
		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—		
Male Right	Concave	—	1	—	1	3	--	3	4	5	10	5	4	6	4	2	2	1	—	1	1	1	1	55	113·10
	Flat	—	—	—	—	2	1	4	—	2	5	1	1	4	1	1	1	—	—	—	—	—	--	23	109·71
	Convex	1	1	—	2	3	1	5	6	11	7	10	5	6	8	5	—	1	2	1	3	2	—	80	112·94
	Totals	1	2	0	3	8	2	12	10	18	22	16	10	16	13	8	3	2	2	2	4	3	1	158	—
Male Left	Concave	—	—	—	—	1	5	8	7	7	7	4	3	2	2	—	3	4	—	1	—	—	—	54	109·95
	Flat	—	—	—	1	1	2	6	3	2	7	3	3	1	2	4	1	1	—	—	1	2	—	40	112·45
	Convex	—	—	3	2	4	8	7	10	9	8	7	8	5	5	1	3	3	—	—	—	—	—	83	108·26
	Totals	0	0	3	3	6	15	21	20	18	22	14	14	8	9	5	7	8	0	1	1	2	0	177	—
Female Right	Concave	—	—	1	—	1	2	6	4	10	5	5	8	8	4	2	3	—	—	1	1	1	--	62	112·50
	Flat	—	—	—	1	—	1	—	1	3	2	1	1	3	—	1	—	1	—	—	—	—	—	15	111·25
	Convex	—	—	—	1	3	1	—	2	8	4	4	1	5	1	1	1	—	2	—	—	1	—	35	111·68
	Totals	0	0	1	2	4	4	6	7	21	11	10	10	16	5	4	4	1	2	1	1	2	0	112	—
Female Left	Concave	—	—	1	1	1	2	1	4	4	10	6	3	4	4	—	—	—	—	—	2	—	—	43	110·78
	Flat	—	1	—	1	1	4	4	1	—	3	4	5	2	2	1	1	1	—	—	—	—	—	31	109·16
	Convex	—	—	1	2	1	3	3	5	7	2	3	4	2	4	1	1	—	—	1	—	—	—	40	108·78
	Totals	0	1	2	4	3	9	8	10	11	15	13	12	8	10	2	2	1	0	1	2	0	0	114	—

Biserial Table. Values of Band-radial Index.

Sex and Side	Curvature	81*	84	87	90	93	96	99	102	105	108	111	114	117	120	123	126	129	132	135	138	141	144	Totals
		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	--	
♂ R.+L.	Concave	—	1	—	1	4	5	11	11	12	17	9	7	8	6	2	5	5	—	2	1	1	1	109
	Not Concave	1	1	3	5	10	12	22	19	24	27	21	17	16	16	11	5	5	2	1	4	4	—	226
	Totals	1	2	3	6	14	17	33	30	36	44	30	24	24	22	13	10	10	2	3	5	5	1	335
♀ R.+L.	Concave	—	—	2	1	2	4	7	8	14	15	11	11	12	8	2	3	—	—	1	3	1	—	105
	Not Concave	—	1	1	5	5	9	7	9	18	11	12	11	12	7	4	3	2	2	1	—	1	—	121
	Totals	0	1	3	6	7	13	14	17	32	26	23	22	24	15	6	6	2	2	2	3	2	0	226

* 81— signifies all values from 80·95—83·95, the indices being recorded by units of ·1.

[1] The paucity of data in this case arises from the frequency with which the epicondyles are too damaged to allow of any determination whatever of the band-radii.

means of arrays that there is only one case—the female left bone—in which the band-radial index decreases regularly, from concave to flat and flat to convex, and then the decrease is only a matter of two points. On the other hand the band-radial index for all four series is greater in the concave than the convex bones, the flat bones—relatively few in number—being anomalous. Such results lead us to expect a very small negative correlation only. This was determined as in the earlier cases and led to the values by the biserial method :

$$\text{♂ (R. + L.)},\ r = -\cdot0387 \pm \cdot0479\,; \quad \text{♀ (R. + L.)},\ r = -\cdot1045 \pm \cdot0558.$$

All we can say is that the correlations are both negative, but that neither are significant having regard to their probable errors. Thus these two apelike characters, convexity of popliteal surface and excess of horizontal band-radius, do not appear in man to be sensibly correlated.

We now turn to our second illustration, the search for any link between the presence of the third trochanter and the convexity of the bone. Here the results appear to us of some singularity. The tables are given below and we deduce the following percentages :

3rd Trochanter	Male Right		Female Right		Male Left		Female Left	
	Concave	Not Concave	Concave	Not Concave	Concave	Not Concave	Concave	Not Concave
Marked	15·38	26·92	17·05	30·26	22·22	18·63	34·21	31·25
Absent	57·69	52·11	50·00	47·37	47·62	49·07	36·84	34·38

Relation of Third Trochanter to Curvature of Popliteal Surface.

Third Trochanter	Male Right				Female Right				Male Left				Female Left			
	Concave	Flat	Convex	Totals	Concave	Flat	Convex	Totals	Concave	Flat	Convex	Totals	Concave	Flat	Convex	Totals
I	2	5	3	10	5	1	4	10	4	0	6	10	7	3	4	14
II	10	4	21	35	10	5	13	28	10	9	15	34	19	9	14	42
III	21	7	28	56	29	7	10	46	19	20	32	71	22	19	14	55
IV	45	15	59	119	44	11	25	80	30	26	53	109	28	8	25	61
Totals	78	31	111	220	88	24	52	164	63	55	106	224	76	39	57	172

It is clear that in the right femur of both male and female there is a very considerable increase of cases with marked third trochanter in the convex bone category. On the other hand this predominance does not occur with the left bones of either sex, where indeed there is a difference—insignificant in itself—the other way round. Nor can we assert that the right bone generally is more primitive than the left, and thus more likely to show association of primitive femoral characters[1]. Without further

[1] Thus examining the table on p. 291 we see that convex bones if somewhat more frequent on male right are less so on female right. Again, marked cases of *trochanter tertius* occur : ♂, R. 20·45 °/₀ ; ♂, L. 19 64 °/₀ ; ♀, R. 23·17 °/₀ ; ♀, L. 32·56 °/₀—the only substantial difference being in favour of the female *left* bone.

tests of long series of femora we should hesitate to assert that this anomalous association of convexity of popliteal surface and presence of third trochanter is a reality. All we can draw attention to is the danger of such relationship being screened if we pool right and left members. Thus the correlation as found from the mean square contingency for example of

$$♂ \text{ (R. + L.)} = \cdot 0555 \text{ and of } ♂ \text{ (R.)} = \cdot 2317,$$

the former being insensible and the latter significant if small.

To sum up our results for curvature, we conclude

(i) That convexity of the popliteal surface is a marked character of the anthropoid apes, but concavity is not in the same sense a marked character of man—certainly not a specific character.

(ii) That there are no strong correlations between convexity of the popliteal surface and what may be considered apelike characters in man for example a low band-radial index, or a pyramidal form of that surface.

(iii) The curvature is, however, substantially related to the primary popliteal index, this latter being a much better guide to the curvature than the secondary popliteal index based on Manouvrier's direct and oblique popliteal antero-posterior diameters.

(iv) After the primary popliteal index, the soffit, or popliteal bicondylar index, is most closely related to the curvature and some considerable way behind this the index of lower or distal gracility of the shaft.

In these three cases the association between the characters intraracially is what we might anticipate from evolutionary development—*i.e.* the more concave the popliteal surface the lower is the popliteal index, the less recedent are the lips of the *linea aspera* on springing from the epicondyles and the more gracile is the shaft.

As far as comparative data for the lower races, primogenial man and the apes are as yet available, they will be found under our discussion of the individual indices or in the second part of this chapter.

IX. *Other Indices of Shaft.*

(*a*) *Indices of Gracility.* The Lower or Distal Index of Gracility is an important measure of the midshaft thinning on which much of the gracility of the human femur depends, and which markedly differentiates human from anthropoid femora. Since the transverse thinning of the shaft is accompanied in the human case by an increased antero-posterior diameter we should anticipate a correlation between gracility and pilastry. Since the index of the former = 100 × pilastric transverse diameter/popliteal width, and the index of the latter = 100 × pilastric antero-posterior diameter/pilastric transverse diameter, any three lengths selected at random would show negative *correlation* in these indices, or a lesser index of gracility (*i.e.* greater gracility) would be associated with greater pilastry. The danger of this spurious correlation being interpreted as organic must be borne in mind. The importance of the index of gracility was impressed upon us when considering Klaatsch's comments on the inadequacy of the popliteal index as a criterion between modern man, primogenial man and the anthropoids: see our pp. 9—10 above.

The following table gives a few values of the Index of Distal Gracility:

TABLE X. *Index of Distal Gracility.*

	No.	Value
Gorilla	4	75·0
Orang-utan	3	72·8
Chimpanzee	5	83·3
Gibbon	3	88·4
Pithecanthropus erectus	1	76·7
Neanderthal	1	75·9
Spy	1	69·9
Homo mousteriensis (Hauseri)	1	57·6
La Chapelle-aux-Saints	1	77·8
Galley Hill	1	58·9
Homo aurignacensis (Hauseri)	1	72·7
Cromagnon	5	72·0
Tilbury Femur	1	81·2?
Australians	14	77·26
Maori	15	66·08
"Modern British"	44	66·26
Eskimo	4	66·45
Modern Bavarians	32	67·25
Andamans	12	68·36
17th century Londoners ♂ R.	230	70·74
17th century Londoners ♂ L.	239	71·34
17th century Londoners ♀ R.	180	69·74
17th century Londoners ♀ L.	184	71·74
Negroes	13	72·79

With the exception of our London data the material is of the slenderest, and can only be taken as suggestive. It is all the more important to bear this in mind, as Hepburn has not taken his popliteal section, we think, by absolutely the same methods as ours.

Bumüller uses as his index the ratio popliteal transverse diameter/pilastric transverse diameter, and terms this by the rather inadequate name "transversal index." He measures it only on 32 of his 400 odd Bavarian femora, and without regard to side or sex. Expressed in terms of our index his frequency distribution is:

Index of Gracility	55·6–58·8	58·8–62·5	62·5–66·7	66·7–71·4	71·4–76·9	76·9–83·3	Total
Frequency	3	3	10	9	5	2	32
Mean Pilastric Index	112·6	108·7	104·7	102·7	94·0	91·8	—

which leads to a mean value of 67·25. Underneath each frequency we have placed the corresponding mean value he gives for the pilastric index. Considering that he has merely taken 32 femora, presumably absolutely at random, the graduated change in his pilastric index is a most fortunate if fortuitous result! A consideration of the probable errors of means based on 2, 3 and 5, when the standard deviation of the character is over 6 points, will emphasise the luckiness of the values. It is, however, inconclusive, because as we have already indicated there is spurious correlation involved in the direct correlation of these indices.

Bumüller, it will be remembered (see our p. 228), has discarded all other femoral lengths except the diaphysial length, and he forms an index of the ratio popliteal length to diaphysial length. Our nearest index would be the popliteal shaft index (see p. 39), *i.e.* 100 popliteal length/length of shaft. That index (see Table II, p. 116) indicates that the popliteal length is slightly less than one-third of the shaft length, say ·32[1]. The ratio of popliteal length to trochanteric length lies between

[1] Actually we find 73 ♂ s ·321 and 62 ♀ s ·320 for our Londoners.

·28 and ·29—also for our Londoners. Accordingly we might have anticipated that Bumüller's index will be about ·30, for his diaphysial length must lie somewhere between our shaft length and trochanteric length. The value we find from Bumüller's slender data, 32 Bavarian femora, is roughly ·34. This agrees with his mid-group value for 19 femora of indices of gracility from 62·5—71·4. Practically all his data[1] are involved in:

Index of Gracility	55·6–62·5	62·5–71·4	71·4–83·3	Total
Frequency	6	19	7	32
Popliteal Length/Diaphysial Length	·32	·34	·36	—

We fear that with due regard to the probable errors this is somewhat slender evidence to base any argument that increased gracility means that the popliteal apex is lowered. Our own results as given later appear, however, to confirm this view. We are by no means clear as to the interpretation Bumüller himself puts upon his figures in the paragraph following their presentation.

We can obtain some appreciation of the correlation between the index of gracility and the popliteal shaft index in the following manner: Let i_1, i_2 represent these indices respectively; let t be the transverse pilastric diameter, l the popliteal length, w the popliteal width and s the shaft length; then

$$r_{i_1 i_2} = \frac{V_2 V_t r_{lt} + V_w V_s r_{ws} - V_2 V_w r_{lw} - V_t V_s r_{st}}{V_{i_1} V_{i_2}}.$$

Now the six coefficients of variation are known from Tables III and IV of pp. 164—5, while r_{lt}, r_{lw} and r_{st} are given in Table I, p. 193. But we have not r_{ws}, the correlation of popliteal width and shaft length. We have, however, the correlation of popliteal *length* and shaft length, which since the former is a part of the latter we should expect to be higher than the correlation of popliteal width and shaft length. The mean value of this correlation for the two sides and two sexes is ·2925, and accordingly we should expect the popliteal width and the shaft length to have a correlation below this. Now the correlation of shaft length with both pilastric transverse and bicondylar width is known, and we again may anticipate that the correlation of shaft length and popliteal width will lie between these two, and might very reasonably be interpolated by a formula of the form:

$$r_{sw} = \frac{r_{st}(b-w) + r_{sb}(w-t)}{b-t},$$

where t, w and b are the pilastric transverse, popliteal and bicondylar widths. It will

[1] Bibl. 81, p. 64. Bumüller's results are given in a manner very difficult of interpretation. He writes: "Die sich hiebei ergebende Länge des Planum popliteum war im Maximum der 2,3 Teil der Diaphysenlänge = $^1/_{2,3}$." We presume he means by this the diaphysial length was 2·3 times the popliteal length, but this is hardly what he says. He writes $^1/_{2,8}$, $^1/_{2,9}$, $^1/_{3,1}$ for our ·36, ·34, ·32 respectively. We are, however, far from certain that he does not mean his ratios to be ·28, ·29 and ·31. In which case his mean ·29 would still agree roughly with ours (·32), but his association would be reversed in sign, although his statement of association appears to correspond, as far as we follow it, with ours. Anyhow no reliable results can be based on so few bones.

be found sufficiently approximate to give $(b-w)/(b-t)$ and $(w-t)/(b-t)$ the round values $\frac{3}{4}$ and $\frac{1}{4}$. This leads to the values of r_{sw}:

♂ R. + ·255, ♂ L. + ·215, ♀ R. + ·168, ♀ L. + ·176.

Using these values in the above formula we deduce:

Correlations of Index of Gracility (Lower) and Popliteal Shaft Index.

♂ R. + ·125, ♂ L. + ·041, ♀ R. + ·133, ♀ L. + ·135.

These correlations suffice to indicate that high values of the two indices have a slight positive correlation, the female showing it somewhat more than the male. In other words, in the more gracile bone the popliteal apex will fall rather lower in the shaft. It seems very doubtful whether such inconsiderable associations (which in our case of some 800 bones in four series have probable errors in excess of ·04) could possibly be detected by the examination of 32 femora.

We now return to the problem of the extent to which gracility is associated with pilastry. Our crude correlations taken from Table II, p. 195, are:

Correlations of Index of Distal Gracility and Pilastric Index.

♂ R. − ·397 ± ·038, ♂ L. − ·451 ± ·035, ♀ R. − ·355 ± ·044, ♀ L. − ·513 ± ·037.

The correlations are thus quite substantial and *negative* or the greater the pilaster the more gracile is the bone. But, as we have already remarked, the negative sign and the high values *might* arise solely from the fact that the pilastric transverse diameter occurs in the numerator of one index and the denominator of the other. We therefore asked ourselves the question whether among all the bones with the same pilastric transverse the more gracile have the greater pilaster. In statistical language we calculated the correlation of the two indices for *constant* pilastric transverse.

In order to solve the problem we must find the correlations between the pilastric transverse and the pilastric index and index of gracility. Let i_3 and i_1 represent these indices respectively; let t be the pilastric transverse, a the pilastric antero-posterior diameter, w the popliteal width. Then we can show that to the usual approximation:

$$r_{i_1 t} = (V_t - r_{wt} V_w)/V_{i_1} \text{ and } r_{i_3 t} = (r_{at} V_a - V_t)/V_{i_3},$$

but V_t, V_w and V_a are given in Table III of p. 164, V_{i_1} and V_{i_3} in Table IV of p. 165, and r_{wt}, r_{at} in Table II of p. 195. Thus $r_{i_1 t}$ and $r_{i_3 t}$ are found:

Correlations.

	Pilastric Transverse and Index of Distal Gracility	Pilastric Transverse and Pilastric Index
♂ R.	+ ·2998	− ·6008
♂ L.	+ ·3107	− ·5723
♀ R.	+ ·3384	− ·6253
♀ L.	+ ·4631	− ·6163

Substituting these values in the formula

$$_t r_{i_1 i_3} = (r_{i_1 i_3} - r_{i_1 t} r_{i_3 t})/\sqrt{(1 - r_{i_1 t})(1 - r_{i_3 t})},$$

we obtain:

Correlations of Index of Distal Gracility and Pilastric Index for Constant Pilastric Transverse.

♂ R. − ·233 ± ·041, ♂ L. − ·350 ± ·038, ♀ R. − ·195 ± ·048, ♀ L. − ·326 ± ·045.

Thus there is a quite significant *negative* correlation, notwithstanding that we make the pilastric transverse constant; only about 30 °/꜀ of the larger negative values of the total correlation appears to arise from the spurious source. There is therefore a real organic relation between gracility and the occurrence of the pilaster.

Another interesting point arises out of the analysis. It is easy to see that to the same degree of approximation:

$$r_{i_1 i_3} = (V_a V_t r_{at} + V_w V_t r_{wt} - V_t^2 - V_w V_a r_{wa})/(V_{i_1} V_{i_3}).$$

Accordingly: $$r_{wa} = (V_a V_t r_{at} + V_w V_t r_{wt} - V_t^2 - V_{i_1} V_{i_3} r_{i_1 i_3})/(V_w V_a).$$

But by the equations previously given:

$$V_{i_1} V_{i_3} r_{i_1 t} r_{i_3 t} = V_a V_t r_{at} + V_w V_t r_{wt} - V_t^2 - V_a V_w r_{wt} r_{at}.$$

Hence: $$r_{wa} - r_{at} r_{wt} = \frac{V_{i_1} V_{i_3}}{V_w V_a} (r_{i_1 t} r_{i_3 t} - r_{i_1 i_3}).$$

Again: $$1 - r_{i_1}^2{}_t = (V_{i_1}^2 - V_t^2 - V_w^2 r_{wt}^2 + 2 r_{wt} V_t V_w)/V_{i_1}^2,$$

and: $$V_{i_1}^2 = V_t^2 + V_w^2 - 2 r_{wt} V_t V_w,$$

or, $$1 - r_{i_1}^2{}_t = V_w^2/V_{i_1}^2 \times (1 - r_w^2{}_t).$$

Similarly: $$1 - r_{i_3}^2{}_t = V_a^2/V_{i_3}^2 \times (1 - r_a^2{}_t).$$

Thus finally:

$$\frac{(r_{wa} - r_{at} r_{wt})}{\sqrt{1 - r_a^2{}_t}\sqrt{1 - r_w^2{}_t}} = (r_{i_1 t} r_{i_3 t} - r_{i_1 i_3})/\sqrt{(1 - r_{i_1}^2{}_t)(1 - r_{i_3}^2{}_t)},$$

$${}_t r_{wa} = - {}_t r_{i_1 i_3},$$

or approximately the partial coefficient of correlation of the index of gracility and the pilastric index is the partial correlation of popliteal width and pilastric antero-posterior diameter for constant transverse diameter with the sign changed. In other words, the *organic* relation between increased gracility and increased pilastry is actually based on an increase of popliteal width being associated with an increase of pilastric antero-posterior diameter. It will be seen from an examination of p. 195 that the correlation of popliteal width and pilastric antero-posterior diameter is practically as close as the relation of the pilastric transverse to the antero-posterior diameter of its own section.

Gracility of Shaft and Robusticity of Femur.

We should naturally expect that the more robust a bone, *i.e.* the more gorilloid its character, the less would be its gracility. But such a relation is subject to several considerations, among which we may note: (*a*) a doubt as to the fitness with which our measuremental functions have been selected to represent the conceptions of gracility and robusticity, (*b*) the possibility that the functions selected are by their essential nature correlated (*i.e.* spurious correlation) and therefore that the ideas of gracility and robusticity are in themselves associated independently of any organic connection, and alternately (*c*) whether the atmospheres attaching to the words "gracility" and "robusticity" do not create in themselves a *nexus*, which may not be justified by any scientific definition of the "gracile" and "robust" characters.

The reader will remember that we have adopted the French definition of robusticity, *i.e.* the sum of the diameters of the pilastric section divided by the oblique length, the index as usual being taken 100 times this ratio. Further our index of gracility is 100 multiplied by the ratio of the pilastric transverse diameter to the popliteal width. Accordingly we see that the pilastric transverse occurs in the numerator of both ratios and if the values of the measurements were picked out from the observation records at random there would still be a positive correlation between the two indices or a negative correlation between gracility and robusticity. Thus there may be a fictitious or spurious correlation between these indices. If we increase the transverse pilastric diameter we increase both indices. On the other hand we could have a very gracile shaft with a low pilastric transverse, but if there were an exaggerated pilaster the robusticity might be very large, *i.e.* it is quite possible to combine gracility with robusticity and this combination is interracially more or less a human characteristic. The femur of recent man has become more gracile than those of the greater anthropoids by the reduction of the pilastric transverse diameter while it has compensated in robusticity for this loss by the development of the pilaster. Thus far our gracility and robusticity measures do not seem badly selected, if we take the precaution of investigating their correlation for constant pilastric transverse. But the very same train of ideas suggests that the actual organic relationship of gracility and robusticity depends on the secondary associations of bicondylar width, oblique length and pilastric antero-posterior diameter with pilastric transverse diameter; yet such secondary associations may be small and are wholly free of any conceptions brought to mind by the atmospheres usage attaches to the words "gracile" and "robust," which are customarily taken as opposites rather than as independent attributes. The "opposites" conception in this case arises from the presence of the pilastric transverse in both measuremental functions and we shall free ourselves from this by the use of partial correlation.

We may approach the problem as follows: Let $i_1 = 100\, t/b$ be the distal index of gracility, $i_2 = 100\,(t+a)/l'$ be the robusticity of the femur, where t, a, b and l' are the pilastric transverse, pilastric antero-posterior diameters, bicondylar width and oblique femoral length respectively. As usual σ, v and r will denote the standard deviation, coefficient of variation and correlation coefficient of the characters indicated by the subscripts. Then the following relations are found at once:

$$r_{i_1 t} = (v_t - v_b r_{bt})/v_{i_1},$$

the numerical values of this correlation are given on p. 303,

$$r_{i_2 t} = \left(\frac{\sigma_t + \sigma_a r_{at}}{\bar{t} + \bar{a}} - v_l r_{lt}\right) \Big/ v_{i_2}.$$

Here $\bar{t}$ and $\bar{a}$ are given in Table I, p. 115, σ_t, σ_a in Table I, p. 162, r_{at} in Table II, p. 195, v_l in Table III, p. 164, and v_{i_2} in Table IV, p. 165. The only correlation at present not determined is r_{lt}, that of pilastric transverse diameter with oblique length of femur. It might probably have been thought sufficiently accurate to take the correlation of the pilastric transverse with the shaft length, but we have actually calculated the values of r_{lt}. We find the following results:

Correlation	♂ R.	♂ L.	♀ R.	♀ L.
$r_{i_1 i_2}$*	+ ·356 ±	+ ·135 ±	+ ·379 ±	+ ·421 ±
$r_{i_1 t}$	+ ·300 ±	+ ·311 ±	+ ·338 ±	+ ·463 ±
$r_{i_2 t}$	+ ·299 ±	+ ·360 ±	+ ·194 ±	+ ·178 ±
$r_{i_3 t}$	+ ·563 ±	+ ·515 ±	+ ·610 ±	+ ·634 ±
${}_t r_{i_1 i_2}$	+ ·237	− ·031	+ ·232	+ ·186
Length of Shaft and Pilastric Transverse	+ ·193 ± ·043	+ ·164 ± ·043	+ ·121 ± ·051	+ ·108 ± ·050

* The low value of ♂ L. is anomalous, but is almost obvious on the table itself. Separate tables were formed first by pooling right and left members and gave ♂ R. + L. + ·245 ± ·031 and ♀ R. + L. + ·390 ± ·032, which are close to the mean of R. and L. or ·245 and ·400 respectively.

It will be seen that the moderate correlations between the indices of gracility and robusticity are considerably reduced—even rendered negative in the case of male left—when we take them for constant pilastric transverse. The relation of robusticity and gracility is thus not as close as the "atmospheres" accompanying these words suggest. When the common influence of the pilastric transverse is removed there appears to be a considerable differentiation with side, robusticity being more closely associated with gracility in right than in left bones.

It is well known that there is considerable change of gracility with growth in the case of the human femur. Plates LVIII and LIX are arranged to illustrate this change from the fetus to the adult. Unfortunately it was not possible to procure the femur of a child of five years, but our plates show how marked is the change from the fetus at 6 or 7 months (*A*) to the adult (*H*). We had not enough material available to show a really graduated growth change, but a *single* series of measurements give:

Fetus at 6–7 months ...	... 51·1	Child at 9 years ...	... 46·0
Infant at birth ...	... 48·7	Child at 12 years ...	... 46·3
Child at 15 months ...	... 47·8	Child at 15 years ...	... 50·3
Child at 2–5 years ...	... 42·1	Adult	... 72·9

These values would suggest that gracility is much greater in infancy than in the adult, but that it increases from birth to 2 or 3 years of age. No sound conclusion can, however, be based on isolated individuals, especially when we take into consideration the difficulty of fixing the exact position of the measurements to be made in the case of fetal and young bones[1]. The like changes occur in the greater anthro-

[1] Bumüller has results for what he terms the Lower Transversal Index which amply corroborate (Bibl. 81, SS. 85—7) the above. His Lower Transversal Index is our Index of Distal Gracility. He also gives under the heading "Längen-Dicken Index," an index resembling to some extent the Index of Robusticity of some French writers, *i.e.* 100 Pilastric Circumference/Oblique Length, only Bumüller uses the Diaphysial Length. The terminology is badly chosen. We suggest the names: Primary Index of Robusticity = 100 Sum of Pilastric Diameters/Oblique Length, Secondary Index of Robusticity = 100 Pilastric Circumference/Oblique Length, Tertiary Index of Robusticity = 100 Pilastric Circumference/Diaphysial Length. A fourth index 100 Sum of Pilastric Diameters/Diaphysial Length would be doubtless the best for the fetus and children, because the Oblique Length is not and the Diaphysial Length is easily ascertained, and because the diameters of the pilastric section are more accurately determinable than the circumference. While Bumüller's material shows no definite changes in Pilastric, Platymeric

poids but less markedly in the gibbon. We find, if D. L. stands for Diaphysial Length:

Gorilla	*Chimpanzee*	*Orang-utan*	*Gibbon*
Infant (D. L. 134) 56·4	Infant (D. L. 141) 57·5	Infant (D. L. 111) 55·4	Young (D. L. 164·5) 82·6
Adult (D. L. 287) 75·0	„ (D. L. 160) 63·8	Adult (D. L. 182) 72·8	Adult (D. L. 170·7) 88·4
	Adult (D. L. 262) 83·3		

The loss of gracility in the human femur is really based upon the cylindrical character of the anterior aspect of the shaft between platymeric and popliteal sections and this feature is far more marked as our illustrations show in the adult than the infant bone. In this respect the fetal bone resembles neither that of the adult anthropoid nor those of the majority of cases of primogenial man where the aspect of the shaft is roughly cylindrical. The appearance of the femur as a strut, whose cross-sections are those of equal resistance, is much more marked in the infantile than in the adult case, and far more marked than in the anthropoid femora. The infantile femur in this respect is more closely allied to that of primitive races like the Andaman or Maori than to that of anthropoid or primogenial man[1]. The reader must not confuse the measure of gracility involved in the index of gracility with the fact that infantile and fetal femora enlarged to the same diaphysial length as the adult bone have larger apparent pilastric transverse diameters. It is difficult to obtain a measure of the shaft length on young femora, but the following indices of transverse slenderness indicate that the index of slenderness decreases or the slenderness increases with age:

Fetus at 6–7 months	9·31	Child at 9 years	7·67
Infant at birth	8·21	Child at 12 years	6·21
Child at 15 months	8·47	Child at 15 years	6·15
Child at 2–5 years	8·16	Adult	6·95

---

or Popliteal Indices with growth, the following valuable table indicates the fairly continuous changes in the proportions of the shaft from the fetus to the adult.

Changes of Tertiary Index of Robusticity and Index of Distal Gracility with Growth.

Serial No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Adult
Sex	♂	?	?	♀	♂	?	♀	?	♂	?	?	?	?	?	♂
Stature	200	—	—	366	420	—	540	—	550	c. 880	c. 960	—	—	—	1657
Diaphysial Length	31	50	50	55	58	61	76	76	77	185	206	220	245	255	384·8
Tertiary Index of Robusticity	32·3	30·0	30·0	30·9	31·0	31·1	26·3	25·0	26·0	22·2	23·8	22·5	20·4	20·4	22·8
Index of Gracility (Lower)	42·9	55·6	52·6	45·5	44·4	—	40·6	42·9	46·7	50·0	52·8	48·5	50·0	50·0	67·2
Mean Diaphysial Length				50·8				76·3				222·2			384·8
Robusticity				30·9				25·8				21·9			22·8
Gracility				48·2				43·4				50·4			67·2

The fairly continuous fall in robusticity is in keeping with our photographs. Our measurements given above indicate also that in the extremely young and the adult the gracility of the femur is less, reaching its maximum in childhood at 3 or 4 years.

[1] An exception must be made in the case of *Homo mousteriensis* (*Hauseri*) which owing to its small pilastric transverse has a remarkably small index of gracility.

The adult measured in this series was somewhat below the average human adult value, 7·3 to 7·4, so that it is conceivable that the index increases or slenderness decreases between 15 years and the completion of growth. It is in this index of transverse slenderness that the child is closer to the anthropoid or to primogenial man than to the adult, but he is not so in the index of gracility as we have indicated above. Of course nothing in this statement is opposed to the fact that the femora of infant man and infant anthropoids (see Plate XCI) are more alike than those of the adults.

The Index of Proximal or Upper Gracility is the index which corresponds on the upper half of the shaft to that already discussed for the lower half of the shaft in the preceding pages. It is based on the ratio of the pilastric to the platymeric transverse diameter. The following table contains the chief values we have been able to determine.

TABLE XI. *Index of Proximal Gracility.*

Race	No.	Value	Race	No.	Value
Gorilla	7	100·2	Cromagnon	5	79·3
Orang-utan	3	96·5	Tilbury Femur	1	87·0
Chimpanzee	5	97·5			
Gibbon	3	90·7	Maori	39	72·51
			Moriori	9	75·84
Pithecanthropus erectus	1	83·1?	Negroes	13	84·84
			Eskimo	4	85·13
Neanderthal	1	85·1	"Modern British"	44	86·31
Spy	1	82·9	Andamans	12	88·08
La Chapelle-aux-Saints ...	1	83·3	17th century Londoners ♂ R.	236	88·80
Homo mousteriensis (*Hauseri*) ...	1	78·4	17th century Londoners ♂ L.	247	88·87
Galley Hill	1	73·9	17th century Londoners ♀ R.	179	88·46
Homo aurignacensis (*Hauseri*) ...	1	84·7	17th century Londoners ♀ L.	193	88·74
			Australians	14	89·03

Here modern man with the exception of Moriori and Maori separates the apes from primogenial man. On the other hand as far as our slender and somewhat irregular results for infancy and childhood go we see the infantile femur for this character further removed from the ape than the adult femur and finding its nearest equivalent in such primitive races as Moriori and Maori.

Fetus at 6–7 months ...	67·5	Child at 9 years	83·9
Infant at birth	63·9	Child at 12 years	86·4
Child at 15 months	80·0	Child at 15 years	87·0
Child at 2–5 years	75·0	Adult	88·7

It will be of interest to provide these indices of gracility for the young of the anthropoids. We find the same decrease of gracility with age:

Gorilla	*Chimpanzee*	*Orang-utan*	*Gibbon*
Infant (D. L. 134) 84·8	Infant (D. L. 141) 89·0	Infant (D. L. 111) 79·8	Young (D. L. 164·5) 83·8
Adult (D. L. 287) 100·2	„ (D. L. 160) 88·2	Adult (D. L. 182) 96·5	Adult (D. L. 170·7) 90·7
	Adult (D. L. 262) 97·5		

The character we are considering is associated with the curvature of the lateral and mesial faces of the shaft. It is easy to measure the chord on the lateral face as

the diaphysial length on this face and take as our index the ratio 100 subtense/chord. The determination of the chord on the mesial side is not so easy, but may be taken from the border of the distal epiphysis to the base of the trochanter minor. With these proposals we find:

	Index of Mesial Curvature	Index of Lateral Curvature	Mean
Fetus at 6–7 months	8·69	3·86	6·28
Infant at birth	6·68	8·94	7·81
Child at 15 months	8·02	5·33	6·68
Child at 2–5 years	6·45	10·08	8·26
Child at 9 years	7·35	5·68	6·51
Child at 12 years	5·77	4·93	5·35
Child at 15 years	7·78	4·81	6·29
Adult	6·31	5·32	5·82

It is clear that the values in the first half of the last column are on the whole greater than in the second half, but the results are too irregular for us to be certain that with ampler data a good graduated system would be reached. Probably the curvatures would have to be measured on the chords from platymeric to popliteal sections to obtain an adequate numerical estimate of the concavity of the lateral and mesial borders, which strikes the eye as such a marked difference between the infantile and adult femora.

(*b*) *Soffit Index.* The Soffit Index has been introduced with a view of measuring the character of primogenial man emphasised by Klaatsch, namely the rapid reduction in transverse diameter following on a massive distal epiphysis. We base the Soffit Index on the ratio of popliteal to bicondylar width. The following table contains such data as we have been able to collect on this point.

TABLE XII. *Soffit Index.*

Race	No.	Value	Race	No.	Value
Gorilla	7	57·1	Cromagnon	5	51·5
Orang-utan	4	51·6	Tilbury Femur	—	—
Chimpanzee	6	51·1			
Gibbon	4	42·2	Andamans	11	43·86
			Australians	14	44·91
Pithecanthropus erectus	1	47·4	Negroes	13	45·11
			Maori	11	48·84
Neanderthal	1	45·3	Eskimo	4	51·48
Spy	1	45·8	"Modern British"	136	49·98
Homo Mousteriensis (*Hauseri*) ...	1	49·8?	17th century Londoners ♂ R.	150	49·88
La Chapelle-aux-Saints ...	1	42·9?	17th century Londoners ♂ L.	63	50·08
Galley Hill	1	50·9??	17th century Londoners ♀ R.	99	50·85
Homo aurignacensis (*Hauseri*) ...	1	45·3	17th century Londoners ♀ L.	111	50·86

We see that as in the case of the index of gracility modern man separates primogenial man from the greater anthropoids.

(*c*) *Popliteal Pyramidal Index.* This index which is based on the ratio of popliteal width to popliteal length is a rough measure of the pyramidal form of the popliteal area. We say "rough" advisedly because the position of the popliteal apex is not capable of very accurate determination, especially in the case of the apes, where we can only treat the apex as the position of nearest approach of the margins of the *linea aspera*. Besides our own measurements on the apes we have only the values deduced from Hepburn's measurements, who takes his popliteal length somewhat differently from ours.

The following table contains the values we have been able to collect.

The data are too slender to provide any very definite conclusions. We believe Hepburn's results must be reduced by 25 °/₀ to be comparable with ours. It seems then probable that the apes in this character separate modern from primogenial man.

TABLE XIII. *Popliteal Pyramidal Index.*

Race	No.	Value	Race	No.	Value
Gorilla	7	35·6	Cromagnon	—	—
Orang-utan	5	27·7	Tilbury Femur	—	—
Chimpanzee	2	27·9			
Gibbon	1	13·1?	Andamans	12	26·63
			Australians	14	30·54
Pithecanthropus erectus	1	24·0	17th century Londoners ♂ R.	225	33·41
			17th century Londoners ♂ L.	237	32·70
Neanderthal	1	36·9	17th century Londoners ♀ R.	178	32·79
Spy	1	39·0	17th century Londoners ♀ L.	183	32·88
Homo mousteriensis (*Hauseri*)	1	32·3	Negroes	13	34·08
La Chapelle-aux-Saints	1	33·3?	Maori	15	39·54
Galley Hill	1	30·4	Eskimo	4	45·37
			"Modern British"	41	42·17

(*d*) *Index of Popliteal Skewness.* The reader may be reminded that Manouvrier introduced the measurement of the direct and oblique popliteal antero-posterior diameters with a view of determining the curvature of the popliteal area and thus throwing light on the apelike character asserted for the Trinil femur—practically on the basis of its popliteal convexity. We have discussed the bearing of the Index of Popliteal Skewness on the convexity of the popliteal surface elsewhere: see pp. 288—291. It is not without interest to examine, as far as our limited material permits, the racial values of this index. For our values we are dependent entirely on Hepburn's and our own measurements. The Index of Popliteal Skewness is 100 × Direct popliteal A.P.D./oblique popliteal A.P.D.[1]

Some explanation of the construction of Table XIV is requisite. We have already indicated that Hepburn's measurements of British femora give measurements of the popliteal diameters and thus of the index of popliteal skewness differing very considerably from ours, the source of this divergence having to be sought in his greater length of bone which throws his popliteal section at a relatively lower level for British

[1] 100 *mp*/*mn* in Manouvrier and Hepburn's notation.

TABLE XIV. *Index of Popliteal Skewness.*

Race	Index of Popliteal Skewness	Race	Index of Popliteal Skewness
Gibbon	100·4 (3)	Cromagnon	96·2? (1)
Chimpanzee	97·5 (3)	Tilbury	98·4? (1)
Orang-utan	97·5 (5)		
Gorilla	80·8 (7)*	Guanches	100·3 (2!) [107·40]
Dryopithecus rhenanus	88·9 (1)	Bushmen	97·1 (2!) [104·00]
		Laplanders	93·2 (4) [99·73]
		Eskimos	92·7 (4) [99·25]
Pithecanthropus erectus	"*mn*" appears unknown!	Negroes	92·5 (13) [98·97]
		Australians	92·1 (14) [98·63]
		East Indians	92·0 (10) [98·44]
Neanderthal	116·1 (1)	Andamans	91·0 (12) [97·43]
Homo mousteriensis (*Hauseri*)	109·4 (1)	17th century Londoners	♂ 90·96 (463), ♀ 90·57 (363)
Galley Hill	105·1 (1)	"Modern British" ...	90·96 (44) [97·38]
Spy	104·7 (1)	Chinese	88·60 (2!) [94·85]
		Romano-British ...	88·37 (8) [94·60]
		Maori	88·09 (15) [94·31]
		Malays	85·0 (2!) [90·95]

* By an oversight in our Table of the "Femora of Primogenial Man and Comparatives" in Chapter X the number is given as 3 instead of 7.

bones: see our p. 124[1]. In the cases of the apes we have followed the 1/10 of the diaphysial length rule. The problem is how to get the best out of Hepburn's data for the purposes of a general comparison. After much consideration we have reduced Hepburn's "British" to our 17th century Londoner males by the reducing factor ·9341. We cannot believe that there is any *substantial* difference between the true index for his "British" and our Londoners. He gives two series of British, one from the dissecting room provides an index of 97·43 (27), and the other presumably from disinterments and probably in many cases belonging to individuals of a much earlier period gives 97·29 (17). The results are in good accordance, and are still quite close, 96·20 (16), if an anomalous femur of the last series be omitted. It seems to us accordingly that Hepburn's 97 corresponds closely to our 91 value for this index. In case however the reader objects to this reduction, we have placed the uncorrected values of the racial indices we have calculated from Hepburn's measurements in square brackets. It will be seen that the sole effect of adopting these square bracket values would be to leave our 17th century Londoners in an anomalous position at the bottom of the list. Whichever series we adopt the main feature is clear: recent man links up with primogenial man of the Neanderthal type through primogenial man of the Cromagnon type. Gorilla excepted, the apes separate primogenial man from modern man; he is closer to the apes than to primogenial man. Galley Hill is again closer to the Neanderthal type than to modern man. Within the range of existing man the Guanches are nearest to the Cromagnon type, then follow Laplanders, Eskimos and Negroes, while the Australians judged by this index have a slightly less

[1] We are after longer study by no means sure that this is the only source of divergence between Hepburn and ourselves; it is possible that he and we have not measured Manouvrier's 4 cms. from the same point, although we appear to be using the same terms.

concave popliteal surface than modern Europeans. Towards the bottom of the list with the maximum of concavity are Chinese, Maori, and Malays. The numbers dealt with in many of these cases are far too small to give any security for definite conclusions. What seems clear, however, is that Manouvrier's test would indicate that the Index of Popliteal Skewness if large for *Pithecanthropus erectus* would place that femur farther from the ape and nearer to primogenial man. The humour of the situation may be summed up in the phrase that Hamlet is missing from the play; for nobody—with the possible exception of Professor Dubois—knows the value of *mn* for the Trinil femur[1]. The table, however, suffices to illustrate the point so often referred to in the present chapter—there is no continuous evolutionary series *in one sense* from the anthropoid through any type of primogenial man to primitive man and thence to modern European man.

(*e*) *Indices of Sagittal Proportions.* Corresponding to our indices of gracility, which are the ratios of *transverse* diameters, we may take indices of *sagittal* or antero-posterior diameters. We may term these the *indices of proximal and distal taper.* Thus the *Index of proximal Taper* = 100 platymeric antero-posterior/pilastric antero-posterior diameter and the Index of distal Taper = 100 popliteal antero-posterior/pilastric antero-posterior diameter[2].

With a very straight pilaster, the index of proximal taper might be a measure of the "carinate" form of the anterior surface, but markedly carinate femora might occur without a low value of this index if the posterior surface of the shaft were also markedly bowed. Thus every carinate femur has not of necessity a low index. The Cromagnon femur has an index of proximal taper, however, of about 75·0 as against the 90·0 of modern Europeans, and the 100 of the apes. At first sight this might be considered another character in which modern man is nearer to the apes than primogenial man, but the Neanderthal femora give 95·2 and the Spy femora 91·8, results in close accord with those for recent man. The table on the following page gives such data as we have been able to collect.

It must be remembered that the *smaller* these indices the larger is the taper. We see that for the English femora the upper and the lower tapering is greater on the right than on the left, and greater in the male than the female. We think the probable source of this is to be sought in a relatively larger pilaster in the male than in the female and on the right side than on the left.

There are very inexplicable irregularities in this table, especially in the case of the anthropoids. In the Gorilla and Gibbon the indices of proximal taper are greater than those of distal taper while for the Orang-utan and the Chimpanzee this relation

[1] A request to Professor Dubois to publish with the present memoir a complete system of measurements to be made by him on the Trinil femur, met with the reply that he was preparing a new monograph on the subject. Thus we are still no wiser than we were twenty years ago!

[2] These indices seem to agree with Bumüller's *Oberer Sagittal-Index* and *Unterer Sagittal-Index.* He gives the value of the latter for a number of apes in his Table, S. 112. For 51 Bavarian femora (? side and sex) he finds a mean of 116·6 for the latter (S. 62) and for 217 Bavarian femora a mean of 90·3 for the former (*loc. cit.* S. 41, A, from which the mean can be roughly found).

is reversed and agrees with what appears to be universal in the case of man. This may only be the result of our very inadequate data for the anthropoids, or it may mark a real differentiation deserving fuller study. Turning to the Index of Proximal Taper we see (i) that modern man as represented by the 17th century Londoners is interposed between the apes and primogenial man of Type A, (ii) that Galley Hill and *Homo aurignacensis* (*Hauseri*) appear again as transitional types between primogenial and modern man, (iii) that primogenial man of the Cromagnon type is in this character separated from modern man by the Neanderthal type. On the other hand he approaches closely to various modern primitive races, Andamans, Australians and Maori.

In the case of the Index of Distal Taper we have even less definite material to rely upon as our values for modern primitive man are nearly all deduced from Hepburn's data, and we have already indicated that his measurement of the popliteal diameter does not agree with ours. We think his values must be reduced about 11·6°/꜀ to agree with ours. His actual values of the Index of Distal Taper are: Negroes, 98·43; Andamans, 100·03; Australians, 91·15; Maori, 104·63; Eskimo, 98·84 and

TABLE XV. *Indices of Sagittal Proportions.*

Race	Indices of Taper			
	Proximal		Distal	
	No.	Value	No.	Value
Gibbon	3	100·9	7	96·9
Gorilla	7	100·8	9	91·6
Orang-utan	3	98·8	9	100·7
Chimpanzee	3	98·7	7	100·0
Dryopithecus rhenanus	1	105·3	—	89·9
Pithecanthropus erectus	1	104·0?	1	106·7?*
Neanderthal	1	84·1	1	105·1
Spy	1	83·3	1	109·9
La Chapelle-aux-Saints	1	81·6	1	90·9
Homo mousteriensis (*Hauseri*) ...	1	94·8	1	116·0
Galley Hill	1	90·8	1	118·3
Homo aurignacensis (*Hauseri*) ...	1	89·5	—	—
Cromagnon ...	5	76·8	—	87·3
Tilbury Femur ...	1	74·9	1	85·7?
Maori	40	75·59	15	92·5
Australians ...	14	76·28	14	80·6
Moriori	9	77·17	—	—
Andamans ...	12	78·35	12	88·4
Negroes	13	80·98	13	87·0
Eskimos	4	87·70	4	87·4
"Modern British"	44	89·89	44	95·97
17th century Londoners ♂ R.	236	90·85	228	94·69
17th century Londoners ♂ L.	247	92·93	238	97·20
17th century Londoners ♀ R.	178	91·44	182	93·16
17th century Londoners ♀ L.	193	92·75	188	96·90
Bavarians ...	217	90·31	51	[116·60]†
Negritos	—	—	10	[113·5]†

* Bumüller gives (Bibl. 81, Tabelle S. 112) 96·7 as his *Unterer Sagittal-Index* for the Trinil Femur based on the Dubois plate. His value for 4 gorilla femora is 98·2, considerably higher than ours.

† These measurements are due to Bumüller and are really incomparable and we believe unreliable. He says (Bibl. 81, S. 62) "so wird man selbstverständlich nicht die höchste Stelle des Pilasters als Messpunkt wählen"; on the contrary we are to take the mean antero-posterior diameter of the "Pilasterregion." How this mean is to be found he does not describe. He does, however, say that, if the pilaster be convex posteriorly, it is best to take the *smallest* diameter. It is clear that this change from the usual maximum to the mean or even to a minimum diameter renders all earlier work of no value for comparative purposes, besides which it provides no definite new rule of measurement. We have only included in the above table Bumüller's values as an illustration of the extreme futility that results from the introduction of individual caprice instead of the following of custom in such matters.

"Modern British" 108·57. With these results modified[1] we find that (i) the anthropoids probably separate primogenial man of the Neanderthal type from modern civilised man, (ii) Cromagnon man appears, judging from Hepburn's *modified* values, to be closer to modern primitive than to modern civilised man and is separated by modern civilised man from man of the Neanderthal type, (iii) the Galley Hill femur appears to be not modern but extreme Neanderthal type in this character, most probably owing to its defective pilastric antero-posterior diameter.

In concluding the first part of this chapter we are compelled to admit that our study of these various indices of the shaft does not demonstrate anything like a continuous evolutionary change *in one sense* with the serial order: anthropoids, Neanderthal man, Cromagnon man, primitive modern man, civilised modern man. This defect in serial order may be due to the slenderness of our data, to personal equation in measurement or to want of accurate measurement in many of the noteworthy instances of primogenial man. Still as a whole the suggestion is strong that, while in many features Galley Hill is an intermediate between Neanderthal man and Cromagnon man, there is not an evolution *in one direction only* from the anthropoids to recent man, but with Cromagnon primogenial man culminated in many characters, and has regressed to more apelike values since. Further we note that in most characters of the femur primitive man of to-day is as far removed from primogenial man as modern civilised man; indeed he may be farther removed.

Part II. Comparison of the Femur of Man with those of other Primates

I. Introductory.

In dealing with the general characteristics of the femur of man and with the properties of the shaft we have a considerable amount of fairly reliable material for other races which can be used for comparative purposes, and to avoid exaggeratedly long tables for the individual characters, it has appeared rather advantageous than otherwise to postpone a detailed comparison of the human femur with those of the lesser primates until the second part of this chapter. On the other hand, for the epiphyses, especially the distal epiphysis, our comparative human material is much more slender, and it is easier to combine into single tables our data for all the primates.

In this section, while still retaining the measurements for individual races of primogenial man, and in some cases for individual femora, we have adopted solely as our representative series for Recent Man our 17th century Londoners, not because the English are an especially representative group, but because we have got our constants on far larger series than is usual, and therefore they have lower probable

[1] We must remind the reader that we place no stress on these modifications. *Four* Australian femora of our own give: Index of Popliteal Skewness, 98·1; Soffit Index, 50·65; Index of Proximal Gracility, 83·3; Index of Distal Gracility, 65·7; Index of Proximal Taper, 86·1; and Index of Distal Taper, 108·15. These slender results—with the exception of the first—are neither in accord with Hepburn's nor with our modification of his values. The indices of taper are Neanderthaloid.

errors. Furthermore, we have used identical methods for the Londoners and for the other primates, and accordingly the comparison from *Tarsius* to Londoner is far more valid on the ground of homogeneity of method. For this reason we have preferred generally to confine our attention to the values obtained by ourselves for the apes, rather than to increase our series by combining our measurements with those of other investigators, who most frequently have adopted more or less divergent characters, or used more or less divergent methods of measuring those which bear the same name as our characters do. We have, however, frequently cited their results, when it was desirable to confirm any marked anomaly or peculiarity.

The separation of this primate section from the rest of this chapter has further fitted better with the evolution of our plan for this memoir, where as we progressed with our preparation of it, we found it more and more needful to extend our studies from the anthropoids to the lesser apes.

II. Comparison of the Absolute Size of the Primates.

In this section we shall deal with the absolute size of the femur in the various genera of the primates, taking three typical measurements, the maximum length, the trochanteric length, and the diaphysial length, into consideration. The relative size of the chief primates is so obvious at sight that it is only the finer relations which need be dwelt upon in the following discussion.

Beyond the absolute size as measured by the major lengths something may also result from a consideration of the absolute dimensions of the antero-posterior and transverse diameters of the shaft at the three principal cross-sections. We shall accordingly deal with these in order to throw light on the manner in which the increasing robusticity of the shaft has been gained in the upward ascent of the primates.

We shall start first with a comparison of some of the major lengths.

(*a*) *Maximum Length, Trochanteric Length and Diaphysial Length of Primate Femur.*

The table on the following page gives our comparative data.

Here, as in other cases of absolute size (*e.g.* the Proximal Breadth), it seems desirable to divide the Lemuroidea into two groups, one the smaller Lemuroids with *Tarsius* as type, the other the larger Lemuroids with the true Lemurs as type. The noteworthy point about these two groups is that while in the Tarsiidean group the Trochanteric Length is less than the Maximum Length, in the Lemurine group it is greater[1].

[1] It may be asked how the maximum length can possibly be less than any other length. The answer lies in the definition of the maximum length as the greatest distance between a point on the head and a point on the *mesial* condyle. Even if we extended this definition and took a length from a point on the head to a point on *either* condyle, we should find in certain cases this wider maximum length less than the trochanteric length, owing to the height of the trochanter above the head. If the maximum length of the femur were defined as the maximum length without regard to start or finish, in certain apes it would lie between the top of the great trochanter and the mesial condyle. This would be neither the more narrowly defined maximum length nor the trochanteric length, but the maximum trochanteric length. This is the case with the *Lemurinae* and with all the *Simiadae*. We have not seen this point referred to by any femoralogist, but it is clear that the so-called *maximum* femoral length was fixed owing to the anthropologist regarding man only, and not heeding the problems of comparative femoralogy.

TABLE XVI. *Maximum Length, Trochanteric Length and Diaphysial Length of Femora of Primates.*

	Group	Maximum Length	Trochanteric Length	Diaphysial Length
Lemuroidea	*Galaginae* (6)	61·2	60·8	51·5
	Tarsiidae (2)	64·2	63·9	55·5
	Lorisinae (6)	76·75 Mean 67·38	75·4 Mean 66·70	65·7 Mean 57·57
	Chiromyrdae (2)	124·65	123·75	109·65
	Lemurinae (18)	129·0 Mean 135·12	131·6 Mean 136·58	110·3 Mean 118·63
	Indrisinae (8)	151·7 Mean 101·25	154·4 Mean 101·64	135·95 Mean 88·10
Cebidae	*Hapalinae* (16)	65·9	66·0	57·0
	Nyctipithecinae (8)	88·8	87·9	77·8
	Lagothrix (2)	112·0	110·0	94·7
	Cebus (6)	119·5	119·2	103·7
	Pithecia (2)	129·6	127·3	115·05
	Mycetes (2)	151·65 Mean 130·77	148·75 Mean 128·89	130·65 Mean 113·03
	Brachyurus (2)	155·2	153·9	137·15
	Ateles (4)	223·5	218·1	188·2
Simiadae	*Cercopithecus* (8)	142·1	144·0	123·4
	Macacus (14)	173·3	175·6	149·3
	Semnopithecus (10)	200·6	202·7	174·5
	Cercocebus (4)	219·95 Mean 192·97	222·85 Mean 195·87	191·6 Mean 167·58
	Cynocephalus (8)	228·9	234·2	199·1
	Dryopithecus rhenanus (1)	287·0	284·2	255·9
Simiinae	Gibbon (2)	193·55	192·2	170·7
	Orang (5)	236·7	219·2	182·2
	Chimpanzee (2)	314·55	311·0	261·8
	Gorilla (4)	♂ 368·35	370·75	309·1
	Gorilla (3)	♀ 309·0 342·91 Mean 298·05	304·9 342·81 Mean 291·00	253·0 285·06 Mean 243·02
	Pithecanthropus erectus	455·0	437·0	394·0
Primogenial Man	Neanderthal Type	423·0	406·5	354·0
	Galley Hill	424·0	?	< 370·0
	Cromagnon	528·0	511·0	[462]
	Grimaldi Type	[480·0]	[467·0]	—
	H. aurignacensis (*Hauseri*)	425·0	410·0	c. 374
Recent Man	Australians	♂ 471·6	—	—
		♀ 426·3	—	—
	Berbers and Guanches	♂ 449·9	422·8	—
		♀ 424·2	398·7	—
	Negroes	♂ 451·7	—	—
		♀ 415·7	—	—
	17th century Londoners	♂ 447·24	425·81	378·14
		♀ 409·19	389·16	347·02
	Neolithic Europeans	♂ 444·0	—	—
		♀ 410·0	—	—
	Maori and Moriori	♂ 440·7	421·8	—
		♀ 407·3	402·0	—
	Fuegians	♂ 433·7	420·4	—
		♀ 403·5	390·2	—
	N. American Indians	♂ 421·6	397·2	—
		♀ 389·9	368·1	—
	Japanese, Aino	♂ 408·0	388·0	—
	Indo-Chinese	♀ 381·0	361·0	—

Mean ♂ 440·9, ♀ 407·5

Mean ♂ 412·7, ♀ 384·9

[Mean ♂ 378·1, ♀ 347·0]

Now this subdivision of the Lemuroids leads us to a most interesting fact: With one possible exception, the *Hapalinae*[1], where the maximum and trochanteric lengths are sensibly equal, all the genera measured of the *Cebidae* have a maximum length greater than their trochanteric length, and this is of course true of the *Cebidae* as a whole. On the other hand, for every single genera of the *Simiadae*, and therefore for the whole family, the trochanteric length is greater than the maximum length. This relative size of the maximum and trochanteric femoral lengths thus serves to differentiate *Cebidae* from *Simiadae*, and also differentiates the *Lemurinae* and *Indrisinae* from the rest of the Lemuroids. Accordingly the suggestion may be made that the *Cebidae* are derived from a form approximating to the Tarsiidean, and the *Simiadae* from a form approximating to the Lemurine group of the Lemuroids. From this standpoint it would be of undoubted interest to have a full study of the femora of the Lemuroids from the North American Eocene deposits and their comparison with the European fossil *Adapinae*.

We note the usual increases in size from Lemuroids to *Simiadae* and so to *Simiinae*; then in the *Hominidae* size increases from Neanderthal to Cromagnon Type and falls again to Recent Man. The fossil Gibbon, as represented by *Dryopithecus rhenanus*, stands in absolute size between Orang and Chimpanzee, and the modern Gibbon represents a diminution in size by 48 %. It may be argued that all the *Simiinae* are degenerates in size, but the more rational view is that the Greater Anthropoids have developed to a maximum utile size with a view to strength, while the Gibbon has diminished to the minimum utile size with regard to agility[2]. Now if we turn to *Pithecanthropus erectus* we note that Schwalbe in his descent, *Pithecanthropus*—Neanderthal Man—Recent Man, has overlooked, for what it is worth, this question of absolute size. *Pithecanthropus erectus* had a stature of 166·8 cms., or a femur length about equal to that of the average male Rothwell English, or those of the male Guanches or British neolithic men. If we suppose the trinil femur not to be that of Recent Man, we must hold that *Pithecanthropus*' immediate predecessors had a femur of the size-order of the fossil Gibbon or something about that of the recent Greater Anthropoids. Thus we have the see-saw: the rise from Anthropoid to *Pithecanthropus*, then, the fall to the Neanderthal Type, the rise to the Cromagnon Type and the fall again to Recent Man. These size change fluctuations—less serious indeed than ratio change fluctuations—still confirm what we have advanced elsewhere in this monograph, *i.e.* that the predecessor of Neanderthal and of Recent Man must be credited with a troglodyte rather than a hylobatic—to say nothing of a completely "Recent Man"—femur.

(*b*) *Epiphysial Development and Diaphysio-epiphysial Index.*

While all three lengths place the genera of primates in the same size-order, yet if we take the absolute difference, Maximum Length less Diaphysial Length, the size-

[1] In this point the marmosets are closer to the Old World monkeys than the bulk of New World monkeys are. The marmosets are usually described as the lowest group of American monkeys. They are very frequently raised into a separate family, the *Hapalidae*.

[2] Possibly in the same manner that *Ateles* among the New World monkeys has developed to much the same size, in this case again a maximum utile size with regard to agility.

order only remains the same for the *Simiadae*. In other words, the development of the epiphyses has not proceeded in all genera *pari passu* with the development of the diaphysis. If we divide the above absolute difference by the diaphysial length itself we obtain an index which will be a *rough* measure of the development in each genus of the epiphyses relative to that of the diaphysis. We may term this index, the ratio being of course multiplied by the usual 100, the Diaphysio-epiphysial Index.

The results are indicated in the next table.

TABLE XVII. *Epiphysial Development and Diaphysio-epiphysial Index.*

	Genus	Maximum Length—Diaphysial Length		Genus	Diaphysio-epiphysial Index	
Lemuroidea	*Tarsiidae* (2)	8·7	Mean 13·15	*Indrisinae* (8)	11·6	Mean 15·59
	Galaginae (6)	9·7		*Chiromyrdae* (2)	13·7	
	Lorisinae (6)	11·05	Mean 9·82	*Tarsiidae* (2)	15·7	
	Chiromyrdae (2)	15·0		*Lorisinae* (6)	16·8	
	Indrisinae (8)	15·75	Mean 16·48	*Lemurinae* (18)	16·95	
	Lemurinae (18)	18·7		*Galaginae* (6)	18·8	
Cebidae	*Hapalinae* (16)	8·9		*Pithecia* (2)	12·6	
	Nyctipithecinae (8)	11·0		*Brachyurus* (2)	13·2	
	Pithecia (2)	14·55		*Nyctipithecinae* (8)	14·1	Mean 15·49
	Cebus (6)	15·8	Mean 17·74	*Cebus* (6)	15·2	
	Lagothrix (2)	17·3		*Hapalinae* (16)	15·6	
	Brachyurus (2)	18·05		*Mycetes* (2)	16·1	
	Mycetes (2)	21·0		*Lagothrix* (2)	18·3	
	Ateles (4)	35·3		*Ateles* (4)	18·8	
Simiadae	*Cercopithecus* (8)	18·7		*Cercocebus* (4)	14·8	
	Macacus (14)	24·0		*Cynocephalus* (8)	15·0	
	Semnopithecus (10)	26·1	Mean 25·39	*Semnopithecus* (10)	15·0	Mean 15·22
	Cercocebus (4)	28·35		*Cercopithecus* (8)	15·2	
	Cynocephalus (8)	29·8		*Macacus* (14)	16·1	
	Dryopithecus rhenanus (1)	31·1		*Dryopithecus rhenanus* (1)	12·2	
Simiinae	Gibbon (2)	28·85		Gibbon (2)	16·9	
	Chimpanzee (2)	52·75		Chimpanzee (2)	20·1	
	Orang (5)	54·5	Mean 54·96	Gorilla (7)	20·5	Mean 23·50
	Gorilla (7)	57·62		Orang (5)	29·9	
	Pithecanthropus erectus (1)	61·0		*Pithecanthropus erectus* (1)	15·5	
Hominidae	Neanderthal Type	69·0		Neanderthal Type	19·5	
	Recent Man (17th century Londoners)	♂ 69·10, ♀ 62·17	65·63	Recent Man (17th century Londoners)	♂ 18·3, ♀ 17·9	18·1

While certain changes in the serial order of size arise if we consider only the epiphysial portion of the maximum length, they are not of much importance except in the case of the Greater Anthropoids. There are no changes in the *Simiadae*; in the *Cebidae* only such changes as might well arise from the smallness of our samples of certain of the genera. In the *Lemuroidea* our Tarsiidean and Lemurine groups still remain apart, if the order within the groups has been modified by the *Tarsiidae*

changing places with the *Galaginae* and the *Indrisinae* with the *Lemurinae*. The most interesting point, however, is that the Orang now replaces the Chimpanzee, standing next to the Gorilla for epiphysial development, in this case chiefly that of the distal epiphysis, which shows for the *Simiinae* a relatively high patellar surface.

If we turn to the Diaphysio-epiphysial Index we note at once that its mean value is practically the same for Lemuroids, *Cebidae* and *Simiadae*; if anything the monkeys have a slightly lower value than the Lemuroids. But the range of the Lemuroid genera covers the whole range of the genera of *Cebidae* and a good deal more than covers the range of genera of the *Simiadae*. In fact, the range of variation is considerably less in the lesser ape genera than in the Lemuroid genera.

The serial order within the families is quite changed, however, from that of absolute size, thus indicating that in the genera the relative development of diaphysis and epiphyses has been entirely different. Thus in the *Lemuroidea*, the genus of largest size, the *Indrisinae*, has had least development of the epiphyses relative to the diaphysis, and the *Galaginae*, the least in size, the greatest. On the other hand, in the *Cebidae*, *Ateles*, the greatest in size, has had the greatest development of the epiphyses relative to the diaphysis, while the *Hapalinae*, the least in size, has the mean development of epiphyses relative to diaphysis. With the *Simiadae*, however, we return to the Lemuroid relations, for *Cercopithecus* and *Cynocephalus*, the least in absolute size, show the greatest development of epiphyses relative to diaphysis, and *Cercocebus* and *Macacus*, the greatest in size, show the least development. This rule also practically applies to the Greater Anthropoids, where the Orang, least in absolute size, has an exceptionally high development of epiphyses relative to the diaphysis, and the Gorilla, greatest in absolute size, has a Diaphysio-epiphysial Index only just about equal to that of the far smaller Chimpanzee. Even in the *Hominidae*, Neanderthal, with the least size, has the greatest development of the epiphyses relative to the diaphysis, and with Recent Man, with the greater size, that development is less.

Thus—notwithstanding the apparent exception of the *Cebidae*[1]—it appears to be the rule that in general short femoral shafts are associated with relatively large epiphyses and large femoral shafts with relatively small epiphyses.

We have seen that the mean Diaphysio-epiphysial Index remains very nearly the same for *Lemuroidea*, *Cebidae* and *Simiadae*. But with the Greater Anthropoids comes a 54 °/₀ increase. This increase was not maintained in Neanderthal Man, although he is but little below the Chimpanzee, and falls still further in the case of Recent Man. It still remains, however, much above the *Simiadae* level. *Pithecanthropus erectus* is within the human range and is nearer to the human mean than to the fossil Gibbon; it is, however, closer to the Recent Gibbon than to Recent Man,

[1] The exception is not so great as it appears at first sight, *Brachyurus* and *Pithecia* in the second half of the table for size are in the first half for Diaphysio-epiphysial Index; *Lagothrix* and *Hapalinae* in the first half for size pass to the second half for index; *Nyctipithecinae* advance one place in the right direction, while *Cebus*, *Mycetes* and *Ateles* are the exceptions to the rule in that they do not change their serial position, but they do not move in the wrong direction.

although we should have anticipated that if it were a forerunner of Man it would be nearer to the fossil than to the Recent Gibbon. Clearly the present adds another to the cases in which Man is interposed between the *Simiadae* and the Greater Anthropoids. This does not, however, signify that Man is even for this character nearer to the fossil Gibbon than to the Recent Chimpanzee.

III. Bowing of the Primate Femur.

We are able to extend considerably our ideas of bowing in the primate femur from fuller data for the lesser apes. In the first place the mean bowing of the Lemuroids is *negative*, and this fact should be taken in association with the appearance of what we have termed the "frontal pilaster": see Plate LXV and the Table of Measurements of the Primate Femur in Atlas, Part II.

Table XVIII. *Indices of Bowing in Primates.*

	Group	Primary Index		Group	Secondary Index	
Lemuroidea	*Lorisinae* (6)	−2·4	Mean −·54	*Tarsiidae*	29·7	Mean 43·05
	Galaginae (6)	−1·35		*Lorisinae*	30·9	
	Tarsiidae (2)	−1·25		*Chiromyrdae*	39·9	
	Lemurinae (18)	0·0		*Galaginae*	44·4	
	Indrisinae (8)	0·6		*Lemurinae*	47·8	
	Chiromyrdae (2)	1·15		*Indrisinae*	65·6	
Cebidae	*Nyctipithecinae* (8)	0·9	Mean 1·87	*Pithecia*	40·55	Mean 46·90
	Pithecia (2)	1·25		*Mycetes*	41·3	
	Cebus (6)	1·45		*Nyctipithecinae*	46·35	
	Lagothrix (2)	1·7		*Brachyurus*	47·75	
	Brachyurus (2)	1·95		*Lagothrix*	48·65	
	Ateles (4)	2·3		*Cebus*	49·0	
	Hapalinae (16)	2·4		*Ateles*	50·3	
	Mycetes (2)	3·0		*Hapalinae*	51·3	
Simiadae	*Semnopithecus* (10)	2·8	Mean 3·50	*Semnopithecus*	43·0	Mean 47·49
	Cercocebus (4)	3·1		*Cercopithecus*	46·2	
	Cynocephalus (8)	3·7		*Cynocephalus*	47·7	
	Macacus (14)	3·8		*Macacus*	49·1	
	Cercopithecus (8)	4·1		*Cercocebus*	51·45	
	Dryopithecus rhenanus (1)	0·6		*Dryopithecus rhenanus*	39·4	
Simiinae	Gibbon (2)	−0·15	Mean 2·71	Gibbon	70·95?	Mean 45·38
	Orang (5)	1·8		Chimpanzee	42·95	
	Chimpanzee (2)	2·95		Orang	45·2	
	Gorilla ♂ (4)	3·5 / 3·37		Gorilla ♂	47·6 / 47·99	
	„ ♀ (3)	3·2		„ ♀	48·5	
	Pithecanthropus erectus (1)	2·8		*Pithecanthropus erectus*	48·7	
Hominidae	Neanderthal Type	3·7	Mean 3·31	Neanderthal Type	53·5	Mean 50·67
	Galley Hill	2·7		Galley Hill	67·1	
	Cromagnon Type	4·3		Cromagnon Type	43·1	
	Grimaldi Type	—		Grimaldi Type	—	
	H. aurignacensis (Hauseri)	—		*H. aurignacensis (Hauseri)*	—	
	Recent Man (17th century Londoners) ♂	2·55 / 2·53		Recent Man (17th century Londoners) ♂	36·85 / 38·99	
	Recent Man (17th century Londoners) ♀	2·50		Recent Man (17th century Londoners) ♀	41·13	

But an analysis of the individual genera shows that in what we have termed the Tarsiidean group (*Lorisinae*, *Galaginae*, and *Tarsiidae*, with possibly the Aye-Aye as a transitional form) the bowing is negative, mean value: $-1{\cdot}7$, while in the Lemurs it is zero, and small and positive in the *Indrisinae*[1]. It will be noticed that the mean secondary index is 35·0 for the Tarsiidean group and 51·1 for the Lemurine group, if we include *Chiromys*, but 56·7 if we exclude it. Thus the point of maximum curvature is more proximal in the case of the less bowing, more distal in the case of the greater bowing. This phenomenon evidenced in the Lemuroids can be traced, not without marked exceptions, higher up in the scale. Thus *Lagothrix*, *Brachyurus*, *Ateles* and the marmosets of the *Cebidae* are among the most bowed and have their points of maximum curvature lowest, *i.e.* their mean primary and secondary indices are 2·1 and 49·5 as against 1·65 and 44·3 for the remainder. *Mycetes* is a bad exception, but again the smallness of the sample must be regarded. *Semnopithecus* illustrates the principle in the *Simiadae*, and to a lesser extent *Macacus*, but *Cercocebus* and *Cercopithecus* are anomic. The Gibbon is very anomalous, but in the case of so small a bowing it is practically impossible to determine with any accuracy the point of maximum curvature. It is true for Recent Man relative to Neanderthal Man, but the Cromagnon Type seems to be an exception. Generally we have:

	Primary Index	Secondary Index
Lemuroidea	−0·54	43·05
Cebidae	1·87	46 90
Simiinae (less Gibbon)	2·71	45·38
Hominidae	3·31	50·67
Simiadae	3·50	47·49

which shows the extent of truth in the rule. At the same time the reader must bear in mind the danger that spurious correlation may be the source of the observed sequences.

What, however, seems clear is that from Lemuroids to Lesser Apes the bowing increases from practical insignificance to very sensible values and that the point of maximum curvature approaches nearer to the middle of the shaft. The gibbons are the only anthropoids which have acquired, or retained, a low bowing. In this respect *Pithecanthropus* is very ungibbonlike, and approaches the Greater Anthropoids, being well, however, within the human range. The Greater Anthropoids are, however, less bowed than the *Simiadae*, and in this respect the Neanderthal Type seems closer to the *Simiadae* than to the *Simiinae*, a relationship found in quite a number of characters. This excess of bowing reaches its maximum in Cromagnon, and then declines in value to Recent Man, who is nearer to the Greater Anthropoids than to Primogenial Man or to the *Simiadae*. Those who place faith in a hylobatic ancestor of man will have grave difficulty in explaining how the marked bowing of the branch-point of the *Simiadae* on the primate stem was lost in that hylobatic ancestor and regained once more with the *Hominidae*. Orderly evolution seems to demand a

[1] Our sample is too small to be certain of the value we give for *Chiromys*.

protsimio-human with the bowing of a troglodyte, and the point of maximum curvature rising somewhat proximally as that bowing is to some extent weakened in Recent Man. As far as we can trust results based on indices both very difficult of accurate determination and showing in the individual species of the genera great variation, bowing further appears to support the view that *Cebidae* are closer to the Tarsiidean, and *Simiadae* to the Lemurine section of the Lemuroids, *i.e.* to the possibility that the New World monkeys were differentiated from their Lemuroid ancestry, before the Lemurine group was fully developed.

IV. Obliquity of the Primate Femur.

The following table gives our results for the various genera of apes and for the types of *Hominidae*. There is a general increase of obliquity from the Lemuroids upwards, culminating in Cromagnon Man and then falling slightly to Recent Man. But certain strange exceptions occur. We note first that the *Cebidae* have rather a low mean obliquity, even below that of the *Lemuroidea*. This is to some extent accounted for by the negative obliquity of the very anomalous *Lagothrix*. If we take *Mycetes*, *Ateles*, *Pithecia* and *Cebus*, with a mean obliquity of 3°·2; this is roughly

Table XIX. *Obliquity of Femur in Primates.*

	Group	Obliquity		
Lemuroidea	*Chiromyrdae* (2) ...	0°·0	Mean 2°·45	
	Indrisinae (8) ...	1°·2		
	Lemurinae (18) ...	2°·2		
	Galaginae (6) ...	2°·1		
	Tarsiidae (2) ...	3°·7		
	Lorisinae (6) ...	5°·5		
Cebidae	*Lagothrix* (2) ...	−2°·2	Mean 1°·66	
	Nyctipithecinae (8)	−0°·1		
	Hapalinae (16) ...	1°·4		
	Brachyurus (2) ...	1°·5		
	Mycetes (2)... ...	2°·0		
	Ateles (4)	3°·35		
	Pithecia (2) ...	3°·4		
	Cebus (6)	3°·9		
Simiadae	*Cercocebus* (4) ...	6°·25	Mean 6°·75	
	Semnopithecus (10)	6°·4		
	Cercopithecus (8) ...	6°·6		
	Macacus (14) ...	7°·2		
	Cynocephalus (8) ...	7°·3		
	Dryopithecus rhenanus (1) ...	4°·0		
Simiinae	Gibbon (2)	3°·0	Mean 2°·48	
	Orang (5)	5°·2		
	Gorilla ♂ (4)	2°·9	1°·83	
	,, ♀ (3)	0°·4		
	Chimpanzee	−0°·1		
	Pithecanthropus erectus (1) ...	12°·0		
Primogenial Man	Neanderthal Type (7) ...	4°·1	Mean 8°·6	
	Galley Hill (1)	8°·5		
	Cromagnon Type (5) ...	12°·5		
	Grimaldi Type (2)	10°·0		
	Homo aurignacensis (*Haus.*)(1)	7°·9		
Recent Man	17th century Londoners ♂ ...	10°·19	10°·4	
	,, ,, ♀ ...	10°·61		

associable with the mean 3°·8 of the Tarsiidean section of the Lemuroids. But the lower values of *Nyctipithecinae* and especially *Hapalinae* are *pro tanto* against the view of a Tarsiidean in contradistinction to Lemurine origin for the *Cebidae*. At any rate that family has made nothing like the progress in femoral obliquity of the *Simiadae*, where again we have another instance of the Old World monkeys outstripping the Anthropoids and being nearer to Recent Man than the latter. Indeed the *Simiinae* present certain noteworthy features. The order of our present table is

practically the same as that on p. 240, although the individuals are far from identical. The negative character of the obliquity in the Chimpanzee and the very small obliquity in the female Gorilla—does this indicate a closer relation in that sex to a Chimpanzee ancestry?—deserve note and if possible confirmation. The relatively low values for the Chimpanzee and Gorilla may be the result of a recent regression, but *Dryopithecus rhenanus* does not suggest much scope in this direction, and it may be better to attribute the higher position of the *Simiadae* to a recent advance[1]. Again, the low value of Man of the Neanderthal Type does not suggest a value higher than 3° to 4° for the protsimio-human, and this would be well out of touch with *Pithecanthropus erectus*, which is quite in the human range, is remote from fossil and recent Gibbons, and has almost the maximum value reached by Cromagnon Man himself. Galley Hill is intermediate between Neanderthal and Cromagnon Man, and the Grimaldi Type indicates the descent from Cromagnon to Recent Man. The rapid rise to Cromagnon and the later descent is parallel to what happens in many characters, and badly needs explanation, but the balance of gain from Neanderthal to Recent Man may very probably be associated with improved uprightness. Is greater uprightness of gait a differential mark between recent and fossil *Simiadae*, or between the Old and New World monkeys?

V. The Midtrochlear Angle of the Primate Femur.

This is the second independent angle of the fundamental triangle of the femur, the Collar Angle being the first. It is the angle which the bust or capito-collar axis subtends at the midtrochlear point, and is the least variable of the three angles of the fundamental triangle. The Lemuroids show the usual difference between the Tarsiidean and Lemurine groups with the customary intermediate position of the *Chiromyrdae*, the Lemurine group pointing as usual in the direction of ascent. The ascent in value is quite appreciable in the *Cebidae*, but more noticeable in the *Simiadae*; for although the midtrochlear angles of *Mycetes* and *Lagothrix* exceed those of *Macacus* and *Cynocephalus*, the *Cebidae* have a number of low values which can only be paralleled by those of the Tarsiidean group of the Lemuroids, and confirm the view previously expressed that the *Cebidae* have closer association with the Tarsiidean group than the *Simiadae*[2].

While the *Cebidae* and *Simiadae* have increased their midtrochlear angles 20°/₀ roughly on the Lemuroids, the Gibbons are only slightly above the mean of the *Simiadae* and show their usual close relationship to *Ateles* (*Dryopithecus rhenanus* 7°·0, *Ateles* 7°·1, Recent Gibbon 7°·25). On the other hand, the Greater Anthropoids have increased 50°/₀ on the *Simiadae*. The increase in the Gorilla is very noticeable, and this character, as so many others, places him quite out of court as a claimant to any close human ancestry. The Chimpanzee, on the other hand, runs fairly parallel

[1] From this standpoint the bowing of the fossil *Simopithecus oswaldi* is of much interest, it is 4·1, close to *Dryopithecus rhenanus* and suggesting but, of course, as a single individual not demonstrating a recent rise in the *Simiadae*.

[2] The range of generic values for this character in the *Cebidae* appears to be quite double that in the *Simiadae*, a fact which suggests a wider range of origin in the former group.

to the Neanderthal Type; Galley Hill is a transition to Recent Man, while the anomalous position of Cromagnon is further evidence of that overshooting of the mark that we have frequently had to note in this "exaggerated recent man" type. The whole of the data suggests a protsimio-human with a midtrochlear angle of about 7°·5. *Pithecanthropus erectus* falls well into the human range, but on the other side of it to what we may suppose the protsimio-human to lie. But the test is of little value, except as confirming others, for a midtrochlear angle of 8°·0 might well alone

TABLE XX. *Midtrochlear Angle in the Primates.*

Group		Midtrochlear Angle		Group		Midtrochlear Angle	
Lemuroidea	*Tarsiidae* (2) ...	4°·3			*Dryopithecus rhenanus* (1) ...	7°·0	
	Galaginae (2) ...	5°·3		Simiinae	Gibbon (2)	7°·25	
	Lorisinae (6) ...	5°·5	Mean 5°·50		Gorilla ♂ (4)...	13°·9	12°·74 (Mean 9°·91)
	Chiromyrdae (2) ...	5°·5			,, ♀ (3)...	11°·2	
	Indrisinae (8) ...	5°·7			Chimpanzee (2)	9°·0	
	Lemurinae (18) ...	6°·7			Orang-utan (5)	8°·0	
Cebidae	*Brachyurus* (2) ...	5°·0			*Pithecanthropus erectus* (1) ...	8°·0	
	Nyctipithecinae (8)	5°·45		Primogenial Man	Neanderthal Type (7) ...	9°·6	
	Pithecia (2) ...	5°·7			Galley Hill (1)	8°·0	
	Hapalinae (16) ...	5°·9	Mean 6°·51		Cromagnon Type (5) ...	6°·7	Mean 8°·26
	Cebus (6)	6°·4			Grimaldi Type (2)	8°·5	
	Ateles (4)	7°·1			*Homo aurignacensis* (*Hauseri*)	[8°·5]	
	Mycetes (2) ...	8°·0		Recent Man	17th century Londoners ♂ ...	7°·85	7°·79
	Lagothrix (2) ...	8°·5			,, ,, ♀ ...	7°·73	
Simiadae	*Cercocebus* (4) ...	6°·25					
	Semnopithecus (10)	6°·4					
	Cercopithecus (8) ...	6°·6	Mean 6°·75				
	Macacus (14) ...	7°·2					
	Cynocephalus (8) ...	7°·3					

and in a single individual indicate a member of the Gibbon, the Chimpanzee or the Human group. The main features of the table are precisely those we have so often met with: the continuous rise in one sense of the character from the *Lemuroidea* to the Greater Anthropoids, the interpolation of the *Hominidae* between *Simiadae* and the Greater Anthropoids, accompanied by a quite sensible fall from Primogenial Man of the Neanderthal Type to Recent Man, which carries the latter somewhat closer still to the Old World monkeys, and the suggestion that the protsimio-human would be more Chimpanzee-like than Gibbon-like, more "Manlike" indeed if we think under that term of a dwarfed and weakened form of Neanderthal Man.

VI. The Torsion of the Primate Femur.

We have on pp. 23—30, 239—242 indicated to the reader the difficulties which attend the interpretation of femoral torsion owing to the want of standardisation in the methods of measurement. In the present table the whole of the data are obtained by a single method except the values for Cromagnon and *Pithecanthropus erectus*, which we have taken from Rodriguez and Dubois respectively. The sole difference

TABLE XXI. *Torsional Angles of Femur in Primates*.*

	Group	Torsion of Femur		Group	Torsion of Shaft		Group	Retorsion	
Lemuroidea	*Lorisinae* (6)	−18°·7		*Lorisinae*	−20°·4		*Lorisinae*	−1°·7*	
	Tarsiidae (2)	−10°·2		*Tarsiidae*	− 3°·0		*Galaginae*	+2°·5*	
	Galaginae (3)	− 3°·0		*Galaginae*	− 0°·5		*Indrisinae*	3°·1†	
	Chiromyrdae (2)	− 3°·0		*Chiromyrdae*	7°·5		*Lemurinae*	4°·25†	* +2°·67
	Lemurinae (18)	7°·4		*Lemurinae*	11°·7		*Tarsiidae*	7°·2*	† +5°·95
	Indrisinae (8)	11°·6	+5°·33 −10°·63 Mean −2°·65	*Indrisinae*	14°·6	+11°·27 −7°·97 Mean +1°·65	*Chiromyrdae*	10°·5†	Mean +4°·31
Cebidae	*Mycetes* (2)	−12°·7		*Mycetes*	−21°·0		*Ateles*	−8°·9*	
	Lagothrix (2)	− 9°·7		*Ateles*	−13°·0		*Mycetes*	−8°·3*	
	Cebus (6)	− 5°·3		*Lagothrix*	− 8°·3		*Lagothrix*	1°·4*	
	Ateles (4)	− 4°·1	−7°·95	*Cebus*	− 1°·5	−10°·95	*Brachyurus*	2°·75†	* −3°·00
	Hapalinae (16)	8°·2		*Hapalinae*	16°·1		*Cebus*	3°·8*	† +6°·81
	Nyctipithecinae (8)	10°·2	+11°·04	*Nyctipithecinae*	17°·5	+17°·88	*Nyctipithecinae*	6°·2†	
	Pithecia (2)	11°·0		*Brachyurus*	16°·4		*Hapalinae*	7°·8†	Mean +1°·90
	Brachyurus (2)	14°·75	Mean +1°·54	*Pithecia*	21°·5	Mean +3°·46	*Pithecia*	10°·5†	
Simiadae	*Cercocebus* (4)	8°·75		*Cercopithecus*	1°·5		*Cercopithecus*	−13°·55	
	Macacus (14)	9°·4		*Semnopithecus*	1°·85		*Semnopithecus*	− 9°·6	
	Semnopithecus (10)	11°·45		*Cercocebus*	4°·0		*Cynocephalus*	− 9°·5	
	Cercopithecus (8)	15°·05	Mean 12°·63	*Macacus*	4°·45	Mean 4°·21	*Macacus*	− 5°·0	Mean −8°·48
	Cynocephalus (8)	18°·5		*Cynocephalus*	9°·1		*Cercocebus*	− 4°·75	
	Dryopithecus rhenanus (1)	13°·5		*Dryopithecus rhenanus*	7°·0		*Dryopithecus rhenanus*	−6°·5	
Simiinae	Gibbon (2)	16°·0		Gibbon	5°·25		Gibbon	−10°·75	
	Orang-utan (5)	− 5°·65		Orang-utan	5°·8		Gorilla ♂	1°·5	
	Chimpanzee (2)	3°·75		Gorilla ♂	11°·25		,, ♀	− 4°·0	−0°·86
	Gorilla ♂ (4)	9°·75		,, ♀	0°·7	6°·73	Chimpanzee	6°·75	
	,, ♀ (3)	4°·7	7°·59 Mean 1°·90	Chimpanzee	10°·5	Mean 7°·68	Orang-utan	11°·45	Mean +5°·78
	Pithecanthropus erectus	15°·0		*Pithecanthropus erectus*	—		*Pithecanthropus erectus*	—	
Primogenial Man	Neanderthal Type	10°·2		Neanderthal Type	23°·4		Neanderthal Type	13°·2	
	Galley Hill (1)	15°·0		Galley Hill	25°·0	24°·2	Galley Hill	10°·0	11°·6
	Cromagnon Type	35°·0	20°·07	Cromagnon Type	—		Cromagnon Type	—	
	Grimaldi Type	—		Grimaldi Type	—		Grimaldi Type	—	
	H. aurignacensis (*Hauseri*)	—		*H. aurignacensis* (*Hauseri*)	—		*H. aurignacensis* (*Hauseri*)	—	
Recent Man	17th century Londoners ♂	13°·21		17th century Londoners ♂	24°·26		17th century Londoners ♂	11°·24	
	,, ,, ,, ♀	16°·13	14°·67	,, ,, ,, ♀	25°·55	24°·90	,, ,, ,, ♀	9°·28	10°·26

* Names without numerical values in this table as in several others are inserted in the hope that the custodians of the bones in question may be induced to supply the missing values.

lies in the application of the method, the measurement of the Apes and Lemuroids being due to Pearson and that of the 17th century Londoners to one of the Laboratory staff working under his superintendence. Unfortunately we have no values for the torsional angles in either *Homo aurignacensis* (*Hauseri*), or in the Grimaldi femora, and none for the torsion of the shaft in Cromagnon.

The results are such as we have already become familiar with in other characters, *i.e.* a rise from Lemuroids to Lesser Apes, a fall in the Greater Anthropoids, but a continuous rise in Primogenial Man as a whole followed by a fall to Recent Man. The details, however, will well repay study.

In the first place we see the Tarsiidean group differentiated from the Lemurine group by the possession of a *negative* torsion, very high indeed in the *Lorisinae*, the Aye-Aye as usual taking an intermediate place. This differentiation into positive and negative groups is maintained in the torsion of the shaft as well as the torsion of the femur as a whole, and is summarised in the following figures:

	Torsion of Femur		Torsion of Shaft		Retorsion	
Tarsiidean Group ...	$-10°{\cdot}63$	$-2°{\cdot}65$	$-7°{\cdot}97$	$+1°{\cdot}65$	$+2°{\cdot}67$	$+4°{\cdot}31$
Lemurine Group ...	$+5°{\cdot}33$		$+11°{\cdot}27$		$+5°{\cdot}95$	

While none of the *Simiadae* shows any trace of negative torsion in the whole femur or in the shaft only, it is exhibited in one-half the genera of the *Cebidae* with which we have dealt, namely, in *Mycetes*, *Lagothrix*, *Cebus* and *Ateles*. On the other hand, the *Hapalinae*, *Nyctipithecinae*, *Pithecia* and *Brachyurus* have positive torsion. If we speak of these for the convenience of the moment as the Mycetean and Nyctipithecine groups we may summarise as follows:

	Torsion of Femur		Torsion of Shaft		Retorsion	
Mycetean Group	$-7°{\cdot}95$	$+1°{\cdot}54$	$-10°{\cdot}95$	$+3°{\cdot}46$	$-3°{\cdot}00$	$+1°{\cdot}90$
Nyctipithecine Group ...	$+11°{\cdot}04$		$+17°{\cdot}88$		$+6°{\cdot}81$	

and write for the *Simiadae*:

Simiadae	$12°{\cdot}63$	$4°{\cdot}21$	$-8°{\cdot}48$

Now even if some of the small negative and positive torsions be fortuitous and due to individual variation, and not to any evolutionary link, still the above manner of looking at the results indicates that there are generic negative torsions in the *Cebidae* and none at all in the *Simiadae*, and thereby suggests that the former group is more closely related than the latter to the Tarsiidean element in the Lemuroids. The inclusion of *Ateles* in the negative torsion group of the *Cebidae* and the exclusion of the primitive marmosets must of course be noted. It is singular that *Ateles*, which in so many characters resembled *Hylobates*, differs in torsional characters so widely from both *Dryopithecus rhenanus* and the Recent Gibbons. Both these have considerable positive torsions and noteworthy negative retorsion, in these matters running very parallel to the *Simiadae*, which have all considerable positive torsions and marked negative retorsion.

The upward rise from negative or small torsions in the Lemuroids to large torsions in the *Simiadae* and the fall from small positive to large negative retorsions, is not

maintained in the Greater Anthropoids. It is true that the torsion of the shaft still continues to increase right up to Recent Man, *i.e.* we have:

	Torsion of Shaft		Torsion of Shaft
Lemuroidea ...	+ 1°·65	*Simiinae*	+ 7°·07
Cebidae	+ 3°·46	Neanderthal Man	+ 23°·4
Simiadae	+ 4°·21	Recent Man ...	+ 24°·9

And this series confirms our belief that the torsion of the shaft is of great evolutionary importance.

But of the Greater Anthropoids the average femoral torsion is only + 1°·90, and the Orang returns to a Tarsiidean condition of negative femoral torsion. The result is manifest in the retorsion, which is only negative in the female Gorilla and has a mean value in excess of any yet met with for the other families of apes.

The position of the *Hominidae* then admits of more than one manner of description because we do not know which of our three torsional characters are to be considered primary. If, as we have suggested (p. 286), the torsion of the shaft is primary as tending to strengthen the femur as a strut by bringing its transverse axis somewhat toward the plane of maximum flexural load and the retorsion primary as tending to rectify the influence of this torsion of the shaft on the general position of the thigh bone, then Man has followed the same line of evolution as the Greater Anthropoids, *i.e.* he has continued in a most marked manner the increasing torsion of the shaft, and the positive retorsion. In this case the increasing torsion in the femur as a whole is only incidental to the above primary factors. On the other hand, if we take the torsion of the femur as a primary factor, we must admit that the evolutionary history of the Greater Anthropoids has diverged considerably from that of Man, who has followed more closely the upward rise in the torsion of the femur taken by the *Simiadae*, while the Greater Anthropoids have reverted to a more Lemuroid condition. Both Anthropoids and Man would then have maintained the upward tendency in the torsion of the shaft, while the marked differences of retorsion in the *Simiadae*, Greater Anthropoids and Man would be merely incidental and of no evolutionary importance. Still a third view may be taken, namely, that the torsional angle of the femur and the retorsion are the primary factors—and this view receives some support from the fact that their absolute variations are less than those of the torsion of the shaft: see Table, p. 162—and that the torsion of the shaft is of no evolutionary importance. In this case the *Simiadae* increased one important factor and the Greater Anthropoids the other, while Man came between the two and increased both.

Whichever interpretation be given—and we shall probably not be able to settle between them, until we know more of the relation of torsion to (i) strut strength in the shaft and (ii) uprightness of gait—the low torsional angle of the Greater Anthropoids is noteworthy[1]. We can hardly believe—in view of the *Simiadae* value—that the protsimio-human had a less value of the torsional angle than the 10° of

[1] The values in the present table are fairly in accord with the much longer series chiefly due to other femoralogists in the Table on p. 243 of this Chapter. The Orang has still negative torsion; the Gorilla has a value which might well arise from a somewhat larger proportion of females; the Chimpanzee value accords within the limits of our small sample. The only serious difference is that of the much longer Gibbon series. Our value is halved and thus brought much further out of accord with *Dryopithecus rhenanus*.

Neanderthal Man, and if so the Greater Anthropoids in their recent forms must have regressed on this, while Primogenial Man advanced enormously to the Cromagnon value, whence as usual the character recedes to the Recent Man value. Taken as a whole many unsolved problems are suggested by this discussion of torsion in the primate femur. We want much better data for Primogenial Man.

VII. On the Diameters and Indices of the Fundamental Sections of the Primate Shaft.

(*a*) *Diameters and Index of the Platymeric Section.*

Let us look first at the platymeric index. We note at once that the mean platymeric index for the Lemuroids does not show a high degree of platymery, and that the

Table XXII. *Diameters and Index of Platymeric Section.*

	Group	Platymeric A.P. Diameter	Platymeric Transverse Diameter	Platymeric Index
Lemuroidea	*Tarsiidae* (2)	3·1	3·5	*Chiromyrdae* 82·95
	Galaginae (6)...	4·0	3·9	*Indrisinae* 87·8
	Lorisinae (6)	4·5	4·9	*Tarsiidae* 88·85
	Chiromyrdae (2)	7·05	8·5	*Lorisinae* 91·2
	Indrisinae (8)	7·45 Mean 5·70	8·65 Mean 6·39	*Lemurinae* 91·6 Mean 91·65
	Lemurinae (18)	8·1	8·9	*Galaginae* 107·5
Cebidae	*Hapalinae* (16)	4·0	4·4	*Nyctipithecinae* 85·5
	Nyctipithecinae (8)	4·6	5·55	*Cebus* 86·8
	Pithecia (2)	6·7	7·6	*Pithecia* 88·2
	Cebus (6)	6·9	8·2	*Brachyurus* 88·5
	Brachyurus (2)	7·7 Mean 7·81	8·7 Mean 8·69	*Hapalinae* 91·2 Mean 90·20
	Mycetes (2)	8·95	9·65	*Mycetes* 92·75
	Lagothrix (2)...	9·1	9·65	*Ateles* 94·3
	Ateles (4)	14·5	15·8	*Lagothrix* 94·35
Simiadae	*Cercopithecus* (8)	9·2	9·5	*Cercocebus* 92·75
	Macacus (14)...	12·3	12·9	*Cynocephalus* 94·9
	Semnopithecus (10)	12·5	12·6	*Macacus* 96·4
	Cercocebus (4)	13·25	14·3	*Cercopithecus* 96·65
	Cynocephalus (8)	15·4 Mean 12·53	16·3 Mean 13·12	*Semnopithecus* 100 2 Mean 96·18
	Dryopithecus rhenanus ...	18·4	20·1	91·5
Simiinae	Gibbon (2)	9·0	10·75	Orang-utan 74·7*
	Orang-utan (5)	15·1	20·3	Gibbon 83·7
	Chimpanzee (2)	21·95 Mean 21·99	26·2 Mean 26·86	Chimpanzee 83·8* Mean 81·13
	Gorilla ♂ (4)...	31·7 } 28·91	37·0 } 34·09	Gorilla ♂ 85·65 } 84·9*
	„ ♀ (3)...	25·2 }	30·2 }	„ ♀ 83·9 }
	Pithecanthropus erectus ...	31·2?	33·2	94·0?
Hominidae	Neanderthal Type (7) ...	26·4	34·1	77·6
	Galley Hill (1)	23·8	35·7	66·7
	Cromagnon Type (5) ...	28·7	39·5	73·0
	Grimaldi Type (2)	31·0	35·0	82·8
	Homo aurignacensis (*Haus.*)(1)	25·5 Mean 26·77	29·5 Mean 33·98	86·4 Mean 78·42
	Recent Man (17th century ♂	26·74 } 25·2	31·60 } 30·1	85·22 } 84·0
	Londoners) ♀	23·58 }	28·63 }	82·87 }

division of the Lemuroids into Tarsiidean and Lemurine groups by no means holds for this character owing to the position of the true lemurs[1]. Further, the femur of the lemur actually gives one on handling the impression of platymery. We think the real source of these discrepancies arises from the platymeric section being taken in the subtrochanteric region. The flattening which occurs in certain genera is at the level of or even above the second trochanter rather than below it, and this fact was overlooked when it was settled to take for Man the index in the *subtrochanteric* region. However, as far as general means go, we see that the platymery remains much the same for the *Cebidae* as for the *Lemuroidea*, but decreases markedly with the *Simiadae* with a Platymeric Index of 96·18, an approximately rotund section. Then we come to the Greater Anthropoids with a most marked increase of platymery, the index sinking to 81·13, which is not very far from that of the Recent Gibbon, and is far below that of the *Lemuroidea*. What interpretation can we put on this? It is a change directly opposite in direction to that of the *Simiadae*. If we look to *Dryopithecus rhenanus* for light we see that the Recent Gibbon is more platymeric than the fossil, which has retained much the value found in the Lemuroids or the *Cebidae*. Thus it would appear that *Simiadae* and *Simiinae* have followed quite opposite directions; their common ancestors probably started with an index of about 90 to 91. On the one hand the *Simiadae* increased relatively their antero-posterior diameter, on the other the *Simiinae* increased relatively their transverse diameter, as the following summary roughly indicates:

Increase on Lemuroid Values.

	Antero-posterior Diameter	Transverse Diameter
Cebidae	37·0 °/₀	36·0 °/₀
Simiadae	119·8 °/₀	105·3 °/₀

Increase on *Cebidae* Values.

Simiadae	60·4 °/₀	51·0 °/₀
Simiinae	181·6 °/₀	209·3 °/₀

Increase on *Simiinae* Values.

Neanderthal Man ...	20·1 °/₀	27·0 °/₀
Recent Man ...	19·1 °/₀	12·0 °/₀

Now we see that while the change in the two diameters of the *Cebidae* on the Lemuroids was almost exactly equal, that of the antero-posterior diameter in the *Simiadae* was 14 °/₀ greater. Again, measuring increase from *Cebidae* values, the *Simiadae* have developed 9 °/₀ more rapidly in the antero-posterior and the *Simiinae* 28 °/₀ more rapidly in transverse diameter. In other words, it appears as if it were the rapid growth of transverse diameter in the *Simiinae* which has led to the greatly

[1] Nevertheless the means give us Tarsiidean Group 95·85 and Lemurine Group 87·32. For the *Cebidae* the Mycetean Group gives us 92·05 and the Nyctipithecine Group 88·35, so that as in the case of torsion (see our p. 323) the Mycetean is more closely related to the Tarsiidean and the Nyctipithecine to the Lemurine. On the other hand for this character the *Simiadae* approach closer to the Tarsiidean than to the Lemurine Group, which is not the general rule.

increased platymery. Lastly, when we come to the *Hominidae* we see that Neanderthal Man has maintained the Simiine tendency to develop the transverse diameter at a greater rate than the antero-posterior diameter, while Recent Man has reverted to the tendency of the *Simiadae* and has developed the antero-posterior more rapidly than the transverse diameter. The relatively greater growth of the transverse diameter is maintained in Cromagnon Man, but (judged on Neanderthal Man) practically ceases with Grimaldi Type, when the values of both diameters begin to fall, but the antero-posterior less rapidly than the transverse. Recent Man has fallen on Cromagnon Man much less in antero-posterior than in transverse diameter. The final result is that for this character he is definitely more like the Chimpanzee or Gorilla than Neanderthal Man was.

(*b*) *Diameters and Indices of the Pilastric Section.*

While the diameters of the first three Lemuroid genera show the same differentiation from the last three as in the case of the platymeric section, the high pilastric indices of the *Tarsiidae* and *Galaginae* are not supported by that of the *Lorisinae*[1]. The *Cebidae* show a moderate fall on the *Lemuroidea*, the *Simiadae* a slight fall, being thus less differentiated from the Lemuroids for this character than the *Cebidae*. But when we come to the Greater Anthropoids, the nearly rotund average femur of the *Lemuroidea* and the *Simiadae* is replaced by a very elliptic one owing to a great increase of the pilastric transverse diameter. The fall in the index of the Greater Anthropoids on the Lemuroid value is 20, and on the *Simiadae* value 19 points! This change does not denote a loss of pilaster so much as a change from a rotund to a maliform shape. At the same time there are more signs of incipient pilaster in some of the Macaques and Baboons than we find in the Greater Anthropoids. With the *Hominidae* comes again the swing of the pendulum, the pilastric transverse develops more rapidly than the antero-posterior, and the result is that the pilastric index in Recent Man agrees with that of *Macacus* and not with Greater Anthropoid values. In marked contrast to the other *Simiinae* is the Recent Gibbon, with a high pilastric index practically identical with that of the Neanderthal Type. Can we look upon this as really strengthening the argument for the hylobatic origin of Man? We think not, for: (i) we believe our small sample has given a fortuitously high value to this index: the value provided in our Table, p. 253, for 41 Recent Gibbons is only 97·1, and this agrees better with the value of the fossil *Dryopithecus* at 98·3. We cannot therefore consider the Recent Gibbon if it has a value much over 100 to have done more than Man has done, *i.e.* acquired it in recent times. (ii) Our own Recent Gibbons have not a high pilastric index because, like Man, they have a pilaster, *i.e.* a pyriform section, but because their section is elliptic with the longer axis in the antero-posterior direction. Thus even if the Recent Gibbon had the pilastric index the same as in Neanderthal Man, we cannot consider it an argument for hylobatic origin. Nor is *Pithecanthropus erectus* proved to be hylobatic

[1] In much the same way the position of *Lagothrix*—the femur of which rarely misses a chance of being anomalous—upsets the Mycetean Group in the *Cebidae*.

Table XXIII. *Diameters and Indices of the Pilastric Section.*

	Group	Pilastric A.P. Diameter	Pilastric Transverse Diameter	Pilastric Index	Group	Index of Sagittal Slenderness	Index of Transverse Slenderness
Lemuroidea	*Tarsiidae* (2)	3·45	2·9	*Tarsiidae* 115·7	*Tarsiidae*	5·6	*Tarsiidae* 4·85
	Galaginae (6)	4·0	3·65	*Galaginae* 111·3	*Indrisinae*	5·6	*Indrisinae* 5·5
	Lorisinae (6)	4·4	4·9	*Indrisinae* 101·7	*Chiromyrdae*	6·4	*Chiromyrdae* 6·5
	Chiromyrdae (2)	7·2	7·4	*Lemurinae* 99·0	*Lorisinae*	6·4	*Galaginae* 6·55
	Indrisinae (8)	7·8	7·6	*Chiromyrdae* 97·3	*Lemurinae*	6·6	*Lemurinae* 6·7
	Lemurinae (18)	7·8	7·9	*Lorisinae* 89·5	*Galaginae*	7·2	*Lorisinae* 7·2
		Mean 5·78	Mean 5·73	Mean 102·42		Mean 6·30	Mean 6·22
Cebidae	*Hapalinae* (16)	3·9	4·1	*Lagothrix* 107·75	*Brachyurus*	5·25	*Brachyurus* 5·1
	Nyctipithecinae (8) ...	4·45	4·7	*Brachyurus* 103·5	*Pithecia*	5·6	*Pithecia* 5·75
	Cebus (6)	6·4	7·0	*Pithecia* 97·8	*Nyctipithecinae*	5·6	*Nyctipithecinae* 5·9
	Pithecia (2)	6·55	6·7	*Hapalinae* 95·1	*Cebus*	6·1	*Cebus* 6·6
	Brachyurus (2)	7·35	7·1	*Nyctipithecinae* 94·9	*Hapalinae*	6·6	*Hapalinae* 6·9
	Lagothrix (2)	8·35	7·75	*Ateles* 94·8	*Mycetes*	6·7	*Mycetes* 7·1
	Mycetes (2)...	8·9	9·45	*Mycetes* 94·25	*Ateles*	6·8	*Ateles* 7·2
	Ateles (4)	13·2	13·9	*Cebus* 91·6	*Lagothrix*...	8·7	*Lagothrix* 8·1
		Mean 7·39	Mean 7·59	Mean 97·46		Mean 6·42	Mean 6·58
Simiadae	*Cercopithecus* (8)	9·7	9·7	*Macacus* 103·4	*Semnopithecus*	6·6	*Semnopithecus* 6·6
	Semnopithecus (10) ...	12·1	12·1	*Cynocephalus* 101·2	*Cercocebus*	6·8	*Cercocebus* 6·75
	Macacus (14)	12·7	12·3	*Cercocebus* 100·7	*Cercopithecus*	7·6	*Cercopithecus* 7·4
	Cercocebus (8)	13·45	13·35	*Semnopithecus* 99·5	*Cynocephalus*	7·9	*Cynocephalus* 7·8
	Cynocephalus (8)	16·0	15·85	*Cercopithecus* 99·3	*Macacus*	8·35	*Macacus* 8·0
		Mean 12·79	Mean 12·66	Mean 100·82		Mean 7·45	Mean 7·31
	Dryopithecus rhenanus (1)	17·8	17·5	98·3	*Dryopithecus rhenanus* ...	7·0	6·9
Simiinae	Gibbon (2)...	9·45	8·75	Gibbon 108·15	Gibbon	5·4	Gibbon 5·0
	Orang (5)	15·8	19·3	Gorilla ♂ 81·9	Chimpanzee	8·3	Chimpanzee 10·5
	Chimpanzee (2)	21·4	25·85	,, ♀ 80·8 81·4	Orang	8·4	Orang 10·2
	Gorilla ♂ (4)	31·5	38·3	Orang 82·1	Gorilla ♂	10·1	Gorilla ♂ 12·35
	,, ♀ (3)	24·7 28·6	30·6 35·0	Chimpanzee 82·8 Mean 82·11	,, ♀	9·6 9·9	,, ♀ 11·9 12·2
		Mean 21·93	Mean 26·72			Mean 8·86	Mean 10·97
	Pithecanthropus erectus (1)	30·0	27·6	108·7	*Pithecanthropus erectus* ...	7·6	7·0
Hominidae	Neanderthal Type... ...	30·5	28·2	108·1	Neanderthal Type ...	8·4	7·8
	Galley Hill	26 2	26·4	99·2	Galley Hill	7·3	7·3
	Cromagnon Type	38·6	30·0	125·1	Cromagnon Type... ...	[8·2]	6·4
	Grimaldi Type	—	29·0	—	Grimaldi Type	—	7·1
	H. aurignacensis (*Hauseri*)	28·5	25·0	114·0	*H. aurignacensis* (*Hauseri*)	7·7	6·8
	Recent Man (17th century Londoners) ♂	29·11	27·99	104·43	Recent Man (17th century Londoners) ♂	7·71	7·43
	♀	25·61 27·36	25·28 26·63	101·61 103·02	♀	7·36 7·54	7·28 7·35
		Mean 30·23	Mean 27·54	Mean 109·88		Mean 7·82	Mean 7·13

because it has a Recent Gibbon (and therefore a Recent Man) value of the pilastric index. The problem can only be answered when we have a drawing of the pilastric section and know whether it is pyriform or elliptic[1]. But if the section be non-pyriform, then we ought to compare the pilastric index of *Pithecanthropus* (108) with *Dryopithecus* (98) and the agreement here is far less than with the *Hominidae*.

We doubt, however, whether in this case—any more than in the case of the platymeric section—it is the index which is of primary evolutionary importance. The Greater Anthropoids developed along the direction of increasing pilastric transverse, we suspect because their gait made the transverse plane that of maximum femoral stress. This was pressed to the extreme in the gorilla. Assuming that man had a more chimpanzee-like than gorilloid progenitor, this development of transverse growth continued through Neanderthal to the Cromagnon type, but with rapidly decreasing intensity. On the other hand the development of the antero-posterior diameter quickened up, and reached its maximum in Cromagnon Man, but the result was not obtained as in the lower primates chiefly by developing a rotiform into an oval cross-section, but by superposing on the fairly rotiform shaft a massive pilaster and so producing a pyriform section. We suspect that Neanderthal Man walked with not a little of an anthropoid gait. How came man with the Cromagnon type to the exaggerated pilaster which more than solved the problem of uprightness? We have not the requisite series—if they existed—of intermediate links to solve the problem, and even the Galley Hill femur, which has partly aided us on other occasions, fails us here owing to the defective condition of its pilastric region. Cromagnon may have been a saltatory mutation, but if so a mutation not only of bones, but of an elaborate musculature, not only correlated together, but correlated with an almost new and most advantageous method of progression! It is difficult to believe in such a saltatory mutation occurring fortuitously and one looks with confidence to the ultimate discovery of types intermediate between Cromagnon (or indeed Recent) Man and Neanderthal (or indeed, if that be treated as a branch line, Troglodytic) Man.

Summary of results just indicated:

	Pilastric Antero-posterior Diameter	Pilastric Transverse Diameter	Ratio
Cebidae on *Lemuroidea*	27·9 °/₀	32·5 °/₀ ...	0·86
Simiadae on *Lemuroidea*	121·3 °/₀	120·9 °/₀ ...	1·00
Chimpanzee on *Simiadae*	71·5 °/₀	104·2 °/₀ ...	0·69
Neanderthal Man on Chimpanzee	42·5 °/₀	9·1 °/₀ ...	4·67
Cromagnon Man on Chimpanzee ...	80·4 °/₀	16·1 °/₀ ...	4·99
Recent Man on Chimpanzee ...	27·9 °/₀	3·0 °/₀ ...	9·30

Thus while relative to the *Lemuroidea*, the *Simiadae* had practically equal development of both diameters, the Chimpanzee shows a greatly preponderating growth of the transverse diameter, emphasising the tendency in this direction of the *Cebidae*. The *Hominidae* all show on the other hand a preponderating development on the Chimpanzee values of the antero-posterior diameter, and although the two diameters for Recent Man are both less than those for either type of Primogenial Man, still the

[1] The drawings of the Trinil femur seem to indicate at least some pilastric development.

relative rate of growth—the ratio of the percentage increases—has continued in one sense, and in Recent Man is nearly double that for Neanderthal Man.

The indices of slenderness are attached to the table on p. 328 to indicate the manner in which the pilastric diameters have changed relatively to the length of the shaft. We see at once that for *Cebidae*, *Simiadae* and *Simiinae* the orders of slenderness, sagittal and transverse, are absolutely the same. They are very nearly the same for the *Lemuroidea* the only change being that of the *Galaginae* and *Lorisinae* in the last three genera. Further the degree of slenderness is very nearly the same transversely and sagittally, for *Lemuroidea*, *Cebidae* and *Simiadae*. It is markedly unequal in the *Simiinae*, but has been partially, if not wholly, restored in Recent Man. The *Cebidae* show only a very slight decrease in slenderness on the *Lemuroidea*; the *Simiadae* advance a point, but the Greater Anthropoids advance $2\frac{1}{2}$ points in sagittal, $4\frac{1}{2}$ points in transverse, slenderness on the Lemuroids. The Recent Gibbon is almost as slender as *Tarsius*, while *Dryopithecus rhenanus* agrees with *Ateles*. With Man we find a reversion to the *Simiadae*, and here as in a number of other characters to which we have drawn attention the *Hominidae* are closer in their most recent forms to the monkeys than to the Anthropoids. The protsimio-human will for both indices of slenderness probably have a value of 8 to 9 and the most like him of the *Simiinae* will undoubtedly be the Chimpanzee.

(c) *Diameters and Indices of the Popliteal Section.*

This third fundamental section largely confirms what we have learnt from the earlier two. We can summarise as follows the development of the diameters:

Rates of Increase of Popliteal Diameters.

	Antero-posterior Diameter	Transverse Diameter	Ratio
Cebidae on *Lemuroidea*	27·4 %	46·6 % ...	0·59
Simiadae on *Lemuroidea*	128·5 %	129·4 % ...	0·99
Greater Anthropoids on *Simiadae*	76·1 %	134·8 % ...	0·56
Neanderthal Man on Chimpanzee	36·0 %	17·3 % ...	2·08
Cromagnon Man on Chimpanzee	56·5 %	32·8 % ...	1·72
Recent Man on Chimpanzee ...	11·7 %	10·0 % ...	1·17

It will be seen from this that in the New World monkeys there was a greater rate of development of the transverse diameter, but that in the Old World monkeys the developments of both diameters were nearly equal. With the Greater Anthropoids it is the transverse diameter which is emphatically developed. But with the *Hominidae* comes a change; the greater development is now in the antero-posterior diameter, and the increase is very considerable in the ratio from Greater Anthropoids to Neanderthal Man; Cromagnon carries on the tendency if less markedly than Neanderthal, but with Recent Man comes a fall in this tendency of a marked character, probably resulting from the progress towards flat and concave popliteal areas, checking the development of the antero-posterior diameter. It should be noted that for all three fundamental sections of the femur the antero-posterior diameter has developed at a greater rate in the *Hominidae* and the transverse diameter in the Greater Anthropoids. The development of the latter in the Greater Anthropoids has always

been relatively greater than in the *Simiinae*. The result is that pilastric, platymeric and popliteal indices all show low values for the Greater Anthropoids, and a rise again in Man. But this rise again of the indices does not indicate a fall of the human transverse diameters below that of the apes. Those diameters continue to increase, but at a

TABLE XXIV. *Diameters and Index of Popliteal Section.*

	Group	Popliteal A.-P. Diameter	Popliteal Transverse Diameter	Popliteal Index
Lemuroidea	*Tarsiidae* (2)	3·15	3·05	*Tarsiidae* 106·6
	Galaginae (6)...	4·0	4·5	*Galaginae* 87·2
	Lorisinae (6)	4·1	6·85	*Lemurinae* 84·2
	Chiromyrdae (2)	6·8	8·85	*Indrisinae* 81·6
	Indrisinae (8)	7·1 Mean 5·43	8·6 Mean 6·78	*Chiromyrdae* 76·85 Mean 82·79
	Lemurinae (18)	7·4	8·8	*Lorisinae* 60·3
Cebidae	*Hapalinae* (16)	3·8	5·0	*Hapalinae* 76·1
	Nyctipithecinae (8)	4·5	6·45	*Mycetes* 74·35
	Pithecia (2)	5·55	7·5	*Pithecia* 74·1
	Cebus (6)	6·1	8·8	*Nyctipithecinae* 70·2
	Brachyurus (2)	6·35 Mean 6·92	9·45 Mean 9·94	*Cebus* 69·6
	Mycetes (2)	8·25	11·1	*Brachyurus* 67·25 Mean 70·58
	Lagothrix (2)	8·25	12·4	*Lagothrix* 66·55
	Ateles (4)	12·55	18·8	*Ateles* 66·5
Simiadae	*Cercopithecus* (8)	9·4	12·0	*Cercocebus* 84·7
	Semnopithecus (10)	11·8	15·2	*Macacus* 82·8
	Macacus (14)...	12·5	15·3	*Cercopithecus* 79·3
	Cercocebus (4)	12·85 Mean 12·41	15·15 Mean 15·55	*Semnopithecus* 77·3 Mean 80·22
	Cynocephalus (8)	15·5	20·1	*Cynocephalus* 77·0
	Dryopithecus rhenanus (1) ...	16·0	25·2	63·5
Simiinae	Gibbon (2)	8·65	11·1	78·2
	Orang-utan (5)	16·7	25·4	65·9
	Chimpanzee (2)	23·45 Mean 21·85	34·35 Mean 36·45	68·25 Mean 61·84
	Gorilla ♂ (4)...	27·95, 25·40	54·7, 49·6	51·1, 51·36
	„ ♀ (3)...	22·0	42·9	51·7
	Pithecanthropus erectus ...	32·0	36·0	88·9
Hominidae	Neanderthal Type	31·9	40·3	79·4
	Galley Hill	31·0	44·8	69·2
	Cromagnon Type	36·7	45·6	81·0
	Grimaldi Type	34·0 Mean 31·96	45·0 Mean 41·32	80·0 Mean 75·80
	Homo aurignacensis (*Hauseri*)	—	[34·4]	—
	Recent Man (17th century ♂	27·97, 26·2	39·65, 37·8	70·84, 69·4
	Londoners) ♀	24·33	35·90	67·92

rate relatively slow compared with the quickened rate of the antero-posterior development. Judged from the standpoint merely of the indices it looks like a regression of Man, especially of Recent Man, to a more apelike character; Man is frequently found to stand between *Simiinae* and *Simiadae*. But looked at from the standpoint of developing diameters we may interpret the changes in the following manner: the Greater Anthropoids exhibit a strong tendency to increase of transverse diameter,

the gain was not lost by the *Hominidae*, but they supplemented it by a pronounced increase of antero-posterior diameter. This growth as far as the pilastric section is concerned is associated with the development of the pilaster, but that is not its sole source for both platymeric and popliteal antero-posterior diameters have also developed largely at the same time; and clearly without such development the pilaster would be of small service[1].

The Popliteal Index of *Dryopithecus rhenanus* carries us back to something like the Greater Anthropoid type, while that of the Recent Gibbon (78·2 for our slender material and 81·4 for 41 individuals, see our table, p. 253) is either recent advance like that of Man, or indicates that the Recent Gibbon cannot claim an ancestor of the *Dryopithecus rhenanus* type and must be placed outside the *Simiinae*. The Gibbon, however, is in so many characters associated with *Ateles*-like forms, that we prefer the former hypothesis, and believe its ancestors to have passed through a low value of the index.

(*d*) *Indices of Popliteal Shape. Soffit Index and Index of Popliteal Skewness.*

There are two further indices of the popliteal area which are tabulated below, namely the Soffit Index and that of Popliteal Skewness. We have indicated on pp. 10, 306–7 and Chapter X the source and the proposed aim of these indices. Taking the second index first into consideration, we see that if Manouvrier's view were correct, the convexity of the popliteal surface in the Tarsiidean group of the Lemuroids would be about that of Neanderthal Man, and that the index fell in both New and Old World monkeys, somewhat more, however, in the former. It fell very rapidly again in the Greater Anthropoids, notably in the gorilla. For the *Hominidae* Neanderthal Man started with the Lorisine value and it has fallen with extreme rapidity to a value in Recent Man only paralleled by that of the Hapalinae and exceeded by that of *Dryopithecus rhenanus*. We believe that the latter value must be regarded as anomalous, it is too remote from both *Ateles* and the Recent Gibbon, and the position of *Dryopithecus* for this index links up with no other kindred form, and is totally out of keeping with the value which we might suppose the ancestors of the *Simiinae* to have taken.

Some explanation is needed of the startling change between the Greater Anthropoids and Neanderthal Man in the value of this index. As a matter of fact Neanderthal Man has a more convex popliteal surface than even the Anthropoids. A glance at our tracings in Chapter X of the popliteal section in Primogenial Man and the Anthropoids shows at once that Neanderthal Man in lessening absolutely his popliteal width compared with that of the gorilla has increased absolutely his direct antero-posterior diameter, *i.e.* what he has lost transversely he has fully replaced sagittally; the result is that his popliteal surface is more convex than that of the gorilla and his oblique popliteal antero-posterior not only became less than that of the gorilla, but shorter

[1] This correlated development could hardly be the product of muscular action, and its existence is a good argument against those who attribute the development of the pilaster to muscular action. The problem whether bone growth produced muscular attachment or muscular attachment bone growth seems allied to the older problem of which, hen or egg, is the source of the other, and indeed admits of the same answer.

TABLE XXV. *Indices of Popliteal Shape; Soffit Index and Index of Popliteal Skewness.*

	Group	Soffit Index		Group	Index of Popliteal Skewness		
Lemuroidea	*Tarsiidae* (2)	44·2		*Tarsiidae*	121·15		
	Chiromyrdae (2)	47·6		*Lorisinae*	111·7	111·35	
	Indrisinae (8)	49·4		*Galaginae*	101·2		
	Lemurinae (18)	49·8		*Indrisinae*	99·7		
	Galaginae (6)	52·8		*Chiromyrdae*	95·8	95·9	
	Lorisinae (6)	57·45	Mean 50·21	*Lemurinae*	92·2		Mean 103·63
Cebidae	*Mycetes* (2)	43·20		*Mycetes*		110·75	
	Cebus (6)	44·3		*Pithecia*		100·9	
	Pithecia (2)	44·65		*Lagothrix*		100·6	
	Brachyurus (2)	47·45		*Cebus*		99·3	
	Nyctipithecinae (8)	49·1		*Brachyurus*		99·2	
	Hapalinae (16)	49·6		*Nyctipithecinae*		96·5	Mean 99·14
	Lagothrix (2)	56·35		*Ateles*		95·0	
	Ateles (4)	57·45	Mean 49·01	*Hapalinae*		90·9	
Simiadae	*Cercocebus* (4)	51·35		*Macacus*		101·9	
	Macacus (14)	52·3		*Cercopithecus*		99·9	
	Semnopithecus (10)	52·6		*Cynocephalus*		96·5	
	Cercopithecus (8)	53·25		*Semnopithecus*		94·8	Mean 97·35
	Cynocephalus (8)	55·1	Mean 52·92	*Cercocebus*		93·65	
	Dryopithecus rhenanus (1) ...	61·3		*Dryopithecus rhenanus* ...		88·9	
Simiinae	Gibbon (2)	43·95		Gibbon		100·6	
	Chimpanzee (2)	49·55		Orang-utan		97·7	
	Orang-utan (5)	50·9		Chimpanzee		93·35	Mean 89·54
	Gorilla* ♂ (4)	59·1	58·63	Gorilla ♂	75·5	77·56	
	„ ♀ (3)	58·0	Mean 53·03	„ ♀	80·3		
	Pithecanthropus erectus (1) ...	46·2		*Pithecanthropus erectus* ...		—	
Primogenial Man	Neanderthal Type (1) ...	45·8		Neanderthal Type		107·6	
	Galley Hill (1)	[50·9??]		Galley Hill		105·1	Mean 106·35
	Cromagnon Type (5) ...	51·5		Cromagnon Type (2) ...		97·3?	
	Grimaldi Type (2)	48·4		Grimaldi Type		—	
	H. aurignacensis (*Hauseri*) (1)	45·3	Mean 48·38	*H. aurignacensis* (*Hauseri*) ...		—	
Recent Man	17th century Londoners ♂ ...	49·99	50·42	17th century Londoners ♂	90·96	90·76	
	„ „ ♀ ...	50·86		„ „ ♀	90·57		

* The reader must remember that all the apes here are of our own measuring. The seven gorillas in this table are not therefore identical with the seven in the second table of Chapter X, the measurements of two of which were taken as there stated from other authors' works. Since that table was printed off the Laboratory has acquired further gorilla bones. Sometimes the reader will find that in special tables we deal with more specimens than are given in the large table of measurements of apes in the Atlas, Part II. This arises from the fact that femora of Anthropoids have been lent to us occasionally for short periods, and were used for any tables which were at that time in preparation.

than his direct diameter. He got in fact a more rotund shaft in the popliteal region. We are inclined to believe that this arose from a transfer of the plane of maximum bending moment from a transverse plane in the case of the troglodyte femur to a nearly sagittal plane in the case of the human femur. If we are to suppose such a value of the

index of popliteal skewness to have long existed in the ancestors of Neanderthal Man, we should have to pass by even *Macacus* and form our link to the main primate line with something like *Mycetes* or even further back with the *Lorisinae*. The fact that this high index of popliteal skewness vanishes almost suddenly[1] suggests that it had not been long acquired and would not probably be found in the protsimio-human.

The Soffit Index is seen from the present table to have a singularly constant value in each of the great primate families. It falls but one point from Lemuroids to *Cebidae*. It rises three points from Lemuroids to *Simiadae*, whose value is essentially the same as that of the Greater Anthropoids. In Primogenial Man the value appears to be low for Neanderthal Man, but to have risen to the Recent Man value with Cromagnon or slightly exceeded it; that value itself is precisely what we started with, that of the Lemuroids. The value of *Dryopithecus rhenanus* is now exceptional but it receives some support from *Ateles*. The low value of the Recent Gibbon is anomalous, linking up with neither *Simiinae*[2] nor *Simiadae*; in fact we have to go back to the *Cebidae* to find a parallel in *Mycetes*. It represents, however, the same feature as Klaatsch found in the Neanderthal Type, namely the more or less rapid drawing in of the shaft just above the condyles. Is it an argument for the hylobatic as opposed to a troglodytic ancestry for Man? We believe not, because we hold it to be—judging from *Dryopithecus rhenanus*—a recent acquirement of the Gibbon. From this standpoint also the Trinil femur is seen to be human, lying between Neanderthal and Recent Man, and not that of a *Hylobates giganticus*, to which our nearest approach, short of pure hypothesis, must be the Eppelsheimer femur. Since the actual popliteal width of Neanderthal is greater than that of the mean Greater Anthropoids, we see that the fall in the Soffit Index is solely due to a greater development of the bi-condylar width, especially of the epicondyles.

VIII. Indices of Gracility and Taper of the Shaft of the Primate Femur.

(*a*) *Indices of Gracility.*

(i) The proximal gracility is here measured by the ratio of the pilastric transverse to the platymeric transverse; it is thus a measure of the relative thinning down—hour glass shape—of the centre of the shaft. We see that the proximal gracility of the *Cebidae* is only two points greater than that of the Lemuroids. The *Simiadae*

[1] Note that our cast value for Cromagnon is back at the *Simiadae* value.

[2] This view would not be correct if we could accept without reserve the four values (44·4, 44·4, 42·9, 42·1) obtained from Hepburn's measurements on two chimpanzees. But he has taken the popliteal width by the 4 cms. rule on femora of oblique lengths 298·5 and 260·5 cms. These oblique lengths must correspond roughly to diaphysial lengths of 251·3 and 219·3 cms. Thus according to our rule for the apes they should have been taken at 2·51 and 2·19 cms. and not 4 cms. from the patellar surface border. Accordingly the popliteal widths and therefore the soffit indices would be very much higher than the above values. We find that to drop the popliteal section 2 cms. raises the popliteal width in the chimpanzee about 11 °/₀ or Hepburn's values of the popliteal width in his chimpanzees would need increasing by 8·25 and 9·9 cms., giving values 48·1, 48·1, 47·1 and 46·3 in much closer accordance with ours.

have a gracility which is six points less and this reduction is continued in the Greater Anthropoids so as to be eight points less. In the gorilla indeed it is twelve points less and he actually attains a maximum of shaft strength by an index of gracility over 100, in this being only comparable with *Cercopithecus*. Both therein resemble the Greek column with a slightly greater mid-diameter, *i.e.* barrel, not hour glass shape. With Man the development of the pilaster gave that strength to his femoral strut, which the gorilla had sought by his barrel shaft, and the result was a return to gracility which reached its maximum in the exaggeratedly pilastered Cromagnon, but has fallen considerably in Recent Man, who stands close to the *Cebidae* level. In other words for this character Man has the appearance of reverting to a value more primitively apelike than the *Simiadae*.

Noteworthy in this respect is the position of the Recent Gibbon. It has gained gracility not by developing a pilaster, but by the development of an oval mid-section to the shaft. The Recent Gibbon has far more proximal gracility than *Dryopithecus rhenanus*, which stands at the level of Recent Man and the *Cebidae* (87 to 88). Thus again we are forced to consider the femur of *Hylobates* as differentiating it very markedly from the Greater Anthropoids, and hardly less from the *Simiadae*; it finds its nearest comparatives in the *Cebidae*. This may be merely a resemblance produced by an evolution towards greater agility,—and the Eppelsheimer femur carries us nearer a stage of less gracility,—or it may point to a line of descent for *Hylobates* with a branch point below that of the *Simiadae*.

(ii) The index of distal gracility is measured by the ratio of the pilastric to the popliteal transverse. We see that the index falls continuously (more rapidly in *Cebidae* than *Simiadae*) as we pass from the Lemuroids right up to Recent Man. Thus we see that the evolution of the primate femur has been one in which the shaft treated as a column had a steadily increasing development above the pediment relative to the central development, *i.e.* the trumpet or Eifel Tower form has been continuously emphasised. This is one of the few indices in which the Greater Anthropoids stand as intermediates between the *Simiadae* and Man, if indeed we ought not to say that Recent Man—and he differs very little from Primogenial Man—is not in distal gracility perfectly gorilloid.

Again we see the Recent Gibbon differentiated from the Anthropoids, and still more from the fossil *Dryopithecus*, which in this character is thoroughly human. *Pithecanthropus erectus* is now closer to the Anthropoids than to the *Hominidae*, but he is far from our nearest approach to the hypothetical *Hylobates giganticus*[1].

(*b*) *Indices of Taper.*

(i) *Index of Proximal Taper.* Proximal Taper is measured by the ratio of the platymeric to the pilastric antero-posterior diameter. When the index is over 100 it means that sagittally the shaft is thicker proximally than at the mid-section, when it is

[1] Here again the argument from a single character in a single individual of the race is of very little worth. Our range of variation of the index of distal gracility in Recent Man runs from 58 to 92 and the Trinil femur is 77!

TABLE XXVI. *Indices measuring the Gracility and Taper of the Femoral Shaft in the Primates.*

	Gracility				*Taper*			
	Group	Index of Proximal Gracility	Group	Index of Distal Gracility	Group	Index of Proximal Taper	Group	Index of Distal Taper
Lemuroidea	*Tarsiidae* (2)	83·3	*Tarsiidae*	95·05	*Tarsiidae*	89·9	*Indrisinae*	91·7
	Chiromyrdae (2)	87·1	*Lemurinae*	89·7	*Chiromyrdae*	96·6	*Lorisinae*	92·6
	Lemurinae (18)	89·0	*Indrisinae*	88·3	*Indrisinae*	98·2	*Tarsiidae*	94·2
	Indrisinae (8)	89·0	*Chiromyrdae*	83·6	*Galaginae*	102·2	*Chiromyrdae*	94·4
	Galaginae (6)	94·85	*Galaginae*	79·4	*Lorisinae*	103·0	*Lemurinae*	96·2
	Lorisinae (6)...	99·35	*Lorisinae*	71·6	*Lemurinae*	104·4	*Galaginae*	98·9
		Mean 90·43		Mean 84·61		Mean 99·05		Mean 94·67
Cebidae	*Lagothrix* (2)	80·35	*Pithecia*	89·45	*Mycetes*	100·55	*Pithecia*	84·75
	Brachyurus (2)	81·6	*Mycetes*	85·15	*Hapalinae*	101·3	*Brachyurus*	86·45
	Nyctipithecinae (8)	84·8	*Hapalinae*	82·2	*Pithecia*	102·25	*Mycetes*	92·7
	Cebus (6)	87·4	*Cebus*	79·6	*Brachyurus*	104·75	*Ateles*	94·4
	Pithecia (2)	88·25	*Brachyurus*	75·2	*Nyctipithecinae*	106·4	*Cebus*	95·7
	Ateles (4)	90·5	*Ateles*	74·85	*Cebus*	108·7	*Hapalinae*	97·7
	Hapalinae (16)	92·9	*Nyctipithecinae*	73·9	*Lagothrix*	109·05	*Lagothrix*	98·8
	Mycetes (2)	98·0	*Lagothrix*	62·5	*Ateles*	110·0	*Nyctipithecinae*	100·8
		Mean 87·97		Mean 77·86		Mean 105·38		Mean 93·91
Simiadae	*Cercocebus* (4)	93·35	*Cercocebus*	88·2	*Cercopithecus*	94·2	*Cercocebus*	95·4
	Semnopithecus (10)	95·65	*Cercopithecus*	81·65	*Cynocephalus*	96·5	*Cynocephalus*	96·9
	Macacus (14)	95·7	*Macacus*	80·7	*Macacus*	97·7	*Cercopithecus*	97·9
	Cynocephalus (8)	97·3	*Semnopithecus*	79·1	*Cercocebus*	98·7	*Macacus*	99·0
	Cercopithecus (8)	102·4	*Cynocephalus*	78·85	*Semnopithecus*	105·7	*Semnopithecus*	99·8
		Mean 96·88		Mean 81·70		Mean 98·56		Mean 97·80
	Dryopithecus rhenanus (1) ...	87·1	*Dryopithecus rhenanus* ...	69·4	*Dryopithecus rhenanus* ...	105·3	*Dryopithecus rhenanus* ...	89·9
Simiinae	Gibbon (2)	81·35	Gibbon	78·95	Gibbon	95·2	Gibbon	91·5
	Orang (5)	95·3	Orang	76·1	Orang	95·6	Gorilla ♂	89·4
	Chimpanzee (2)	98·7	Chimpanzee	75·25	Gorilla ♂	101·3	,, ♀	89·2
	Gorilla ♂ (4)...	103·65	Gorilla ♂	70·1	,, ♀	102·2	Orang	105·7
	,, ♀ (3)...	101·6	,, ♀	71·8	Chimpanzee	102·35	Chimpanzee	109·55
		102·77		70·83		101·69		89·31
		Mean 98·59		Mean 74·06		Mean 99·88		Mean 101·52
	Pithecanthropus erectus (1)	83·1	*Pithecanthropus erectus*	76·7	*Pithecanthropus erectus*	104·0??	*Pithecanthropus erectus*	106·7??
Primogenial Man	Neanderthal Type (7) ...	82·4	Neanderthal Type ...	70·3	Neanderthal Type ...	87·2	Neanderthal Type ...	105·5
	Galley Hill (1)	[73·9]*	Galley Hill	[58·9]*	Galley Hill	[90·8]*	Galley Hill	[118·3]*
	Cromagnon Type (5) ...	79·3	Cromagnon Type ...	72·0	Cromagnon Type ...	76·8	Cromagnon Type . .	87·3
	Grimaldi Type (2)	82·3	Grimaldi Type	70·5	Grimaldi Type	—	Grimaldi Type	—
	H. aurignacensis (Hauseri) (1)	84·7	*H. aurignacensis (Hauseri)*	72·7	*H. aurignacensis (Hauseri)*	89·5	*H. aurignacensis (Hauseri)*	—
		Mean 82·18		Mean 71·38		Mean 84·5		Mean 96·4
Recent Man	17th century Londoners ♂	88·83	17th century Londoners ♂	71·04	17th century Londoners ♂	91·92	17th century Londoners ♂	95·97
	,, ,, ,, ♀	88·61	,, ,, ,, ♀	70·70	,, ,, ,, ♀	92·12	,, ,, ,, ♀	95·98
		88·72		70·87		92·02		95·97

* All these indices involve the pilastric diameters, which owing to weathering or other cause appear to us quite unreliable in the case of this femur. These values are accordingly omitted from the means for Primogenial Man.

under 100 the greater thickness is at the mid-section. The latter is the case in the *Hominidae* and we may describe it as *taper proper*; the former is the case for every genera of the *Cebidae* and we may speak of it as *reversed taper*. Taper proper exists in every genus of the *Simiadae* except *Semnopithecus*, and although not as great as in Man serves to differentiate the Old World from the New World monkeys. The genera of the Lemuroids are equally divided, *Tarsiidae*, *Chiromyrdae* and *Indrisinae* have taper proper, while *Galaginae*, *Lorisinae* and *Lemurinae* have reversed taper, thus indicating that variation within the Lemuroid genera practically covers the two classes of taper found in *Cebidae* and *Simiadae*. Turning to the *Simiinae* we see that Gorilla and Chimpanzee follow the *Cebidae* or indeed *Semnopithecus* in showing reversed taper, while the Gibbon and the Orang show taper proper, which is characteristic of the bulk of the genera of *Simiadae*. Turning to the *Hominidae* we note that Neanderthal Man shows a taper proper (87·2) scarcely equalled by that of *Tarsius* (89·9). In the case of Cromagnon Man owing to the development of pilaster in its exaggerated form the proximal taper sinks to 76·8, to rise again, however, in Recent Man to a value (92·0) still below that of all the primate genera discussed except *Tarsiidae*. Putting aside the *Cebidae*, there is but small change in taper from Lemuroids to *Simiinae*, then we have with Primogenial Man the marked fall of 15 points, with an ultimate rise in Recent Man to a value more apelike than in the case of Primogenial Man. It is the case we have so repeatedly noticed of Man being nearer to the lesser apes—in this case the *Simiadae*—than to the *Simiinae*. And this change may again be accounted for either by suggesting that the branch point of the *Hominidae* was lower on the parent stem than the branch point of the *Simiinae*, or by supposing that there has been a special source, *e.g.* the development of pilaster—which has increased the taper proper of the *Hominidae*. If we search for light from *Hylobates*, we see that the fossil *Dryopithecus rhenanus* starts with an amount of reversed taper (105·3), which can only be paralleled by *Semnopithecus* and is more characteristic of the *Cebidae* than of Anthropoids or Old World monkeys. Further we note that this taper has fallen by 10 points in the Recent Gibbon; it is therefore not so inconceivable that a protsimio-human with a taper of about 100—well within the range of the Greater Anthropoids—might lead to a Neanderthal Man of 13 points taper difference, certainly to a Recent Man with only 8 points difference. Of course the development would be simpler if we could give the protsimio-human a value more orangoid than chimpanzee-like. But the high value of the Eppelsheimer femur is rather against this unless we dismissed Hylobates altogether from our Anthropoid series, which we personally should not be sorry to do on the marked evidence of the femur, if one bone only were adequate to settle such a point.

(ii) *Index of Distal Taper.* Distal taper is measured by the ratio of the popliteal to the pilastric antero-posterior diameter. The index ascends, or taper lessens, continuously from Lemuroids through the *Simiadae* to the *Simiinae*; indeed it may be said to increase until it reaches reversed taper in the Orang, Chimpanzee and Neanderthal Man. The latter is therefore closer to the Chimpanzee than to Hylobates, the fossil and recent forms of which are close together, and gorilloid

rather than chimpanzee-like. The fall from Chimpanzee to Gorilla is parallel to the fall from Neanderthal Man to Cromagnon, but is not due to the same cause—the development of the pilaster. The recovery from Cromagnon to Recent Man as usual results in placing the latter nearer to the mean of *Simiadae* than to the mean of the Greater Anthropoids.

IX. Proximal and Distal Breadth Ratios for the Primate Femur.

The discussion of these ratios forms a not inappropriate transition to the topics of the following chapters, which deal with the epiphyses of the femur of the primates. The question they may be supposed to answer is: How have the proximal and distal epiphyses developed relative to the absolute size of the femur, this absolute size being measured at Klaatsch's suggestion by the trochanteric length?

Clearly relative to this standard the proximal breadth increased from *Lemuroidea* to *Cebidae* very slightly, from *Lemuroidea* to *Simiadae* rather more, from *Simiadae* to Greater Anthropoids immensely. Neanderthal Man maintains without sensible increase the Greater Anthropoid value, being three points more than the Chimpanzee and two less than the Gorilla. From Neanderthal there is a drop to Cromagnon, which has a value close to that of Recent Man.

For the Gibbon series we have *Dryopithecus rhenanus* 17·6, Recent Gibbon 15·0, and for comparison *Ateles* 16·0, all values less than the mean value of the *Simiadae*. In the face of such evidence, it is very difficult to accept a hylobatic in preference to a troglodyte ancestry for Man. It is no less difficult to group the Gibbon with the Anthropoids; to do so is to accept a range of 12·5 in the genera of the *Simiinae*, as against 3·2 in the *Simiadae*, 4·0 in the *Cebidae* and 4·4 in the *Lemuroidea*. Roughly the intergeneric variability decreases as we rise in the scale, and a range of 12·5 seems wholly out of place.

Turning now to the Distal Breadth Ratio, we see that relative to the femoral length the distal epiphysis has increased about 2 points from the Lemuroids to the Monkeys, rather more in the *Cebidae* and less in the *Simiadae*. Then comes the great jump of 8 points from *Simiadae* to Greater Anthropoids. This jump is not wholly maintained in the *Hominidae*, the Neanderthal Type having a distal breadth ratio less than the Chimpanzee by about 0·5 points. From Neanderthal Man the fall is considerable through Cromagnon to Recent Man, due chiefly to the great development of shaft which the acquirement of the pilaster permitted, the dimensions of the distal epiphysis not increasing at the same rate.

Just as for the proximal epiphysis the Gibbons hold an anomalous place among the *Simiinae*, if judged by the Distal Breadth Ratio. We have *Dryopithecus rhenanus* 14·5, Recent Gibbon 13·15, and for comparison *Ateles* 15·1, values corresponding to a much earlier stage of femoral development than that of the Greater Anthropoids or of the *Hominidae*. The suggestion again is that of a troglodyte rather than a hylobatic ancestor for Man.

TABLE XXVII. *Proximal Breadth and Distal Breadth Ratios.*

	Group	Proximal Breadth Ratio		Group	Distal Breadth Ratio	
Lemuroidea	*Tarsiidae* (2)	13·4		*Tarsiidae*	10·8	
	Lorisinae (6)	15·2		*Indrisinae*	11·4	
	Indrisinae (8)	15·45	Mean 15·92	*Lemurinae*	13·4	Mean 13·45
	Galaginae (6)	16·4		*Galaginae*	14·4	
	Chiromyrdae (2)	17·25		*Chiromyrdae*	15·0	
	Lemurinae (18)	17·8		*Lorisinae*	15·7	
Cebidae	*Nyctipithecinae* (8)	14·2		*Brachyurus*	12·9	
	Brachyurus (2)	14·55		*Pithecia*	13·2	
	Pithecia (2)	14·85		*Nyctipithecinae*	14·85	
	Ateles (4)	16·0		*Ateles*	15·1	Mean 15·57
	Mycetes (2)	16·75	Mean 16·16	*Hapalinae*	15·3	
	Hapalinae (16)	17·3		*Cebus*	15·9	
	Cebus (6)	17·4		*Mycetes*	17·3	
	Lagothrix (2)	18·25		*Lagothrix*	20·0	
Simiadae	*Cercocebus* (4)	16·15		*Cercocebus*	13·25	
	Semnopithecus (10)	16·2		*Semnopithecus*	14·5	
	Cercopithecus (8)	18·35	Mean 17·88	*Cynocephalus*	15·6	Mean 15·10
	Macacus (14)	19·3		*Cercopithecus*	15·7	
	Cynocephalus (8)	19·4		*Macacus*	16·45	
	Dryopithecus rhenanus (1) ...	17·6		*Dryopithecus rhenanus* ...	14·5	
Simiinae	Gibbon (2)	15·0		Gibbon	13·15	
	Chimpanzee (2)	22·15		Chimpanzee	22·25	
	Gorilla ♂ (4)	27·85	27·06	Orang-utan	22·9	Mean 23·26
	,, ♀ (3)	26·0	Mean 25·57	Gorilla ♂	24·95	24·63
	Orang-utan (5)	27·5		,, ♀	24·2	
	Pithecanthropus erectus (1) ...	21·1		*Pithecanthropus erectus* ...	17·8	
Hominidae Primogenial Man	Neanderthal Type (7) ...	25·1		Neanderthal Type ...	21·6	
	Galley Hill (1)	[24·6?]		Galley Hill	[21·6??]	
	Cromagnon Type (5) ...	21·6		Cromagnon Type ...	19·0	
	Grimaldi Type (2)	22·9	Mean 23·04	Grimaldi Type	19·9	Mean 20·08
	H. aurignacensis (*Hauseri*) (1)	21·0		*H. aurignacensis* (*Hauseri*)	18·3	
Recent Man	17th century Londoners ♂ ...	22·26	22·09	17th century Londoners ♂	18·77	18·45
	,, ,, ♀ ...	21·92		,, ,, ♀	18·13	

In neither Proximal nor Distal Breadth Ratio is *Pithecanthropus erectus* anything but human, and the Trinil femur exhibits no suggestion of Bumüller's *Hylobates giganticus.*

The position of *Lagothrix* in these characters, as in many others, is exceptional and deserves attention. We should like to see a more complete study of the femur—indeed of all the long bones of this monkey.

Concluding Remarks.

(i) The hylobatic group as far as the femur is concerned stands so far apart from the other Anthropoids that the femoralogist alone would scarcely include the Gibbon in this family.

(ii) The fossil *Dryopithecus rhenanus* is closely allied to the Recent Gibbons, and on this ground it might be well to accept Dubois' proposed renaming of *Pliohylobatis eppelsheimensis*. Pohlig's proposed *Paidopithex rhenanus* seems to suggest only Schleiermacher's original blunder[1].

(iii) Our detailed study of the general characters of the femur and of the special characters of its shaft compels us to associate the human femur with those of the Greater Anthropoids, not with that of *Hylobates*, or as we may express it with a troglodytic rather than with a hylobatic origin.

(iv) *Pithecanthropus erectus* is for all the characters we have been able to study human and, what is more important still, recent human, and bears no resemblance to Primogenial Man. In some cases the Trinil femur diverges towards that of the *Recent* Gibbon, but not more than many human femora do. In our opinion these divergences tell rather against than for the hypothesis of *Pithecanthropus* as a missing link between ape and Man. In particular it seems impossible to accept for the femur Schwalbe's *Pithecanthropus*—Neanderthal Man—Recent Man chain. It would involve a more troglodytic form inserted between two "recent human" links. Dubois' arguments that the femur of *Pithecanthropus* is human because he was erect, and that a femur can take a human character without being human[2], seem to us invalid. The femur of Neanderthal Man differs very considerably from that of Recent Man, and probably because he was less erect. We should anticipate that the missing link would in itself be less erect than Neanderthal Man and still less erect than Recent Man, and accordingly the femur would differ still more than that of Neanderthal Man from Recent Man.

If *Pithecanthropus* be an ancestor of Recent Man, all we can say is that the missing links we personally should be excited about would be those that correspond to the branch points in the human ancestry of Neanderthal Man and of the Greater Anthropoids.

(v) We find little if any justification for Bumüller's view that *Pithecanthropus erectus* should be rechristened *Hylobates giganticus*. The nearest approach to such a being is *Dryopithecus rhenanus*, and the Trinil femur just because it resembles that of Recent Man differs widely from that of Eppelsheim.

(vi) We have noticed in a very considerable number of femoral characters a continuous change in one sense from Lemuroids to *Simiadae*, then a big forward step in the same sense to the Greater Anthropoids, and continued still in the same sense from the Greater Anthropoids to Neanderthal Man, with a culmination in Cromagnon Man. After Cromagnon Man the character generally reverses its trend, so that

[1] Bibl. 68 *ter*.

[2] Bibl. 68 *quarter*, p. 159.

Recent Man returns to a position nearer to the Greater Anthropoids, or in some cases nearer to the *Simiadae* than to Neanderthal Man. This apparent reversion to the pithecoid we have frequently had occasion to refer to. We believe it to be of very great significance, because it involves the principle that, if, as we believe, Neanderthal and Cromagnon Men, or branch points approximating to them, are in the direct descent of Recent Man, then intermediate steps between Neanderthal and Cromagnon forms will resemble in a good many of their characters, *but not in all of them*, Recent Man, and may be easily on the basis of inadequate examination mistaken for Recent Man. The most significant deviations from Recent Man would lie in more massive epiphyses—the shape of the distal articular surface, considerable bowing, and probably less pilaster[1]. The view that the Galley Hill femur is that of Recent Man seems to us erroneous (see Chapter X), but we find such grounds as there are for it in the consideration that it was an intermediate in the Neanderthal to Cromagnon series. In the same manner the resemblance of the *Homo aurignacensis* (*Hauseri*) to Recent Man may, we believe, be accounted for. It is like Recent Man because it lies between Neanderthal and Cromagnon; this is emphasised by the fact that it probably was a woman's femur and accounts for the resemblance that Klaatsch finds between it and the Galley Hill femur.

Unfortunately some of the most important characters of this Aurigniac femur are at present unknown or very doubtful; we have no good photographs nor any cast, and we cannot implicitly trust even the measurements which Klaatsch does provide. However, we may note the following characters, wherein to avoid the question of sex we have considered only angles and indices:

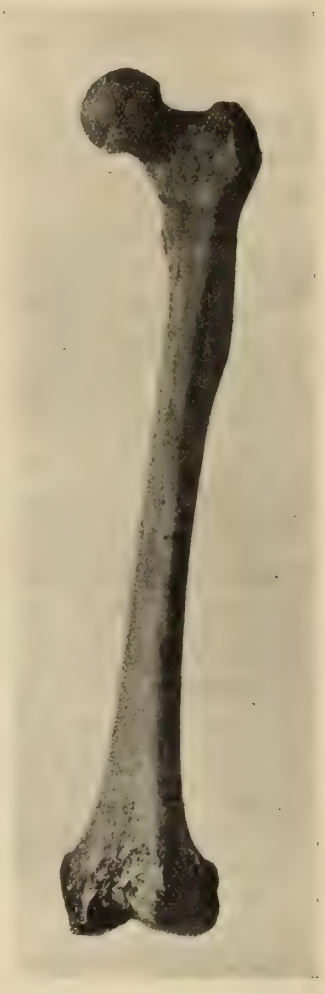
Character	Neanderthal Type	*Homo aurignacensis* (*Hauseri*)	Cromagnon Type	Recent Man
Midtrochlear Angle	9°·6	8°·5	6°·7	7°·8
Collar Angle	115°·0	120°·0	126°·0	130°·0
Lemotic Index	11 ·1	11 ·5	11 ·1	12 ·0
Bust Shaft Index	20 ·2	18 ·8	18 ·7	20 ·0
Capital Ratio	12 ·4	9 ·6	10 ·2	10 ·0
Epiphysial Ratio	83 ·0	92 ·0	92 ·3	96 ·5
Pilastric Index	108 ·1	114 ·0	125 ·1	103 ·0
Soffit Index	45 ·8	45 ·3	51 ·5	50 ·0
Index of Proximal Gracility ...	82 ·4	84 ·7	79 ·3	89 ·0
Index of Transverse Slenderness	7 ·8	6 ·8	6 ·4	7 ·3
Distal Articulation Index ...	79 ·4	85 ·3	88 ·3	89 ·0
Rotular Ratio	3 ·95	4 ·60	5 ·42	5 ·6
Rotular Index	24 ·0	30 ·5	32 ·4	36 ·7
Diaphysial Rotular Ratio ...	4 ·7	5 ·2	6 ·3	6 ·6

It is quite possible to arrange another series of indices—perhaps not quite so impressive as the above—showing that *Homo aurignacensis* (*Hauseri*) lies between Cromagnon and Recent Man. What, then, is our argument? Why, *that where we*

[1] We say *probably* less pilaster, because we have not only to allow for individual variation, but to remember that while Cromagnon Man contributed in broad and exaggerated form the pilaster to the *Hominidae* it was probably started before the appearance of that type and has diminished since.

have only a single individual to judge from, the determination of its associations, even when exact and complete measurements exist, is not a straightforward task, and a brief inspectional assertion that Galley Hill or Hauser's Aurigniac Man are "recent," is worth very little indeed from the standpoint of exact science. All we venture to propound is that both Galley Hill (see Chapter X) and Hauser's Aurigniac Man may well be Neanderthal-Cromagnon intermediates for all the evidence yet presented, and if they should be, then we fear that Klaatsch's double origin of Man, orangoid[1] and gorilloid, falls with the "recent man" attribution of these two femora.

"Frontal Pilaster"



Femur of a Fuegian, reproduced by permission of Prof. Rudolf Martin (*Lehrbuch der Anthropologie*, Fig. 435). This femur combines two primitive anomalies, *i.e.* the lateral protrusion of anterior face and the "frontal pilaster" characteristic of the Lemuroids. Prof. Martin uses this femur to illustrate the combination of marked platymery and sensible pilaster.

(vii) If we endeavour to sum up the associations we have found between Man and the Greater Anthropoids on the basis of our study of the primate femur, we believe it can be best done by a comparison of what appears to us in the roundest and roughest of numbers to have been the general characters of the femur and the special characters of the shaft in the case of the supposed protsimio-human, the branch point of Man and the Greater Anthropoids. We may preface our table of values by saying that we should anticipate no more pilaster than is found in some of the *Simiadae*; there will be very frequently, if it be not indeed a specific character, a *fossa hypotrochanterica*; *slight* lateral protrusion of the anterior face and *slight* ridge form of third trochanter will either be specific or occur more frequently as anomalies than in Recent Man; there might be anticipated to be a broad if short crural trough, bounded occasionally as an anomaly by a "frontal pilaster"—see the accompanying figure and Plate LXV; there will be a poorly marked popliteal apex, and the popliteal surface will be convex, but probably not so markedly

[1] Judging by the characters of the femur, "orangoid" is hardly the correct word, we believe the better opposites would be hylobatic and troglodytic. The latter word weakens down the second or "gorilloid" terminology. Not only is the femur of Neanderthal Man distinctly not gorilloid except to the most superficial examination, but the gorilla is "recent" and lies nowhere close to the supposed troglodytic ancestor of Man, who in many respects would be more human than even chimpanzee-like.

convex as in the case of the Greater Anthropoids or Neanderthal Man; the patellar surface will be more symmetrical, and the upward projection of it on the lateral side of the anterior face will have wholly or partially disappeared; the head will be well defined, but considerably cut away at the top of the neck to mesial border; also the

TABLE XXVIII. *General Characters and Characters of the Shaft for the Hypothetical Protsimio-human.*

	Character	Recent Gibbon	Hypothetical Protsimio-human	Recent Chimpanzee	Recent Man ♂ + ♀
Major Lengths	Maximum Length	193·6	325	314·6	428·22
	Trochanteric Length	192·2	318	311·0	407·45
	Max. Troch. Length	193·1	329	313·4	416·18
	Oblique Length	193·5	322·5	311·6	425·37
	Troch. Obl. Length	192·2	318	311·8	404·60
	Capito-trochlear Length	187·4	301	303·7	413·14
	Diaphysial Length	170·7	273	261·8	363·28
	Length of Shaft	174·9	271·5	257·4	362·42
Shaft	Proximal Breadth	28·8	70·0	68·5	90·10
	Platymeric A.-P. Diameter	9·0	22·7	22·0	25·16
	Platymeric Trans. Diameter	10·8	25·8	26·2	30·12
	Pilastric A.-P. Diameter	9·5	22·8	21·4	27·36
	Pilastric Trans. Diameter	8·8	23·25	25·9	26·63
	Popliteal Width	11·1	31·0	34·4	37·78
	Popliteal Direct A.-P. Diameter	8·7	21·7	23·5	26·15
	Popliteal Oblique A.-P. Diameter	8·6	22·4	25·2	28·76
Angles	Mid-trochlear Angle	7°·3	8°·5	9°·0	7°·79
	Angle at Centre of Head	58°·3	51°·0	37°·8	42°·14
	Collar Angle	114°·5	120°·5	133°·3	130°·39
	Torsion of Shaft	5°·3	15°·0	10°·5	24°·90
	Torsional Angle	16°·0	6°·0	3°·8	14°·77
	Retorsional Angle	−10°·7	9°·0	6°·7	10°·26
	Obliquity of Shaft	3°·0	3°·0	−0°·1	10°·40
General Indices	Obl. Direct Lengths Index	100·0	99·2	99·1	99·30
	Obl. Direct Troch. Lengths Index	100 0	100·0	100·3	99·42
	Proximal Breadth Ratio	15·0	22·0	22·2	22·06
	Distal Breadth Ratio	13·2	19·5	22·3	18·45
	Pithecoid Index	99·3	98·6	100·0	95·25
	Robusticity of Femur	9·4	14·3	15·2	12·70
Indices of the Shaft	Platymeric Index	83·7	88·0	83·8	84·04
	Pilastric Index	108·2	98·0	82·8	103·02
	Popliteal Index	78·2	70·0	68·3	69·38
	Index of Popliteal Skewness	100·6	96·9	93·4	90·76
	Soffit Index	43·9	50·0	49·6	50·42
	Index of Proximal Gracility	81·4	90·0	98·7	88·72
	Index of Distal Gracility	79·0	75·0	75·3	70·87
	Index of Transverse Slenderness	5·0	8·6	10·0	7·35
	Index of Sagittal Slenderness	5·4	8·4	8·3	7·36
	Index of Proximal Taper	95·2	99·6	102·4	92·02
	Index of Distal Taper	91·5	95·2	109·6	95·97
	Primary Index of Bowing	−0·2	3·2	2·95	2·53
	Secondary Index of Bowing	70·95	49·0	43·0	38·99
	Bicondylar Width	25·3	62·0	69·3	74·88

head will be slightly above the great trochanter; the patellar surface will be short to medium height, very slightly elevated above the anterior face and without trace of tongue, except as an anomaly.

Difference in absolute size varies very much with the individual; it may run to 100 mm. in the genera of one primate family, and approaches 100 mm. even in the one species of Recent Man; it is accordingly very difficult to fix on a mean value for our protsimio-human. This is emphasised by the fact that the tendency of recent evolution has been rather towards a decrease in size—evidence of which may be seen in the Gibbon since Pliocene and in Man since Cromagnon times. For mere fixing of ideas we may credit our protsimio-human with a maximum femoral length of 300 to 350 mm. or, say, 325 mm. The stature, if this being had been erect, would have been something less than those of Bushmen or Andamans, and approached nearer to that of the Akkas, say, 120 to 125 cms.

The *absolute* measurements of course depend upon this choice of maximum length and would be modified if this were changed. What we have endeavoured to select are rough values of the general indices and those of the shaft. These were reached by a very careful consideration of what the values were likely to be of the branch points of the *Simiadae* and of the Greater Anthropoids on the main line of human descent. In judging we have supposed that line to pass through the Neanderthal Type, as we hold that the requisite robusticity of the human femur was attained before the pilaster. Accordingly our problem was to carry backward the human line of ascent towards the above branch points. Compromise had of course to be frequently made, but it would require too much space to show the individual reasons for each index value, and after all the matter is of relatively small importance. Till the requisite fossil femur is found our reconstruction remains at best but an *espièglerie*, and when the protsimio-human missing link is found—as found we have no doubt it will be—then all guesswork will be replaced by knowledge, and it will matter little what has been the goodness or badness of previous hypotheses. Science consists not in absolute knowledge, but in the statement of the probable on the basis of our present—invariably limited—acquaintance with facts.

But our table—as those at the ends of the following chapters will do—does sum up the authors' present acquaintance with facts and indicate why a troglodytic rather than a hylobatic ancestry is to be preferred for Man. It will be seen that the indices are as a rule intermediate between those of Recent Gibbon and Recent Chimpanzee, but almost invariably nearer to those of the latter. If Recent Man was evolved from a hylobatic ancestry, even of the *Pliohylobates* type, and not from a line which had acquired the robusticity of the Greater *Simiadae* and of the Greater Anthropoids, it is surprising that he should have acquired such a complex of troglodyte characters as his femur presents. But had he developed on parallel lines, he would hardly have acquired these characters as anomalies, and even then he must have passed through something like a Neanderthal stage to obtain his present robusticity and present proportions of epiphyses and diaphysis. These are undoubtedly troglodytic and not hylobatic.

CHAPTER VIII

CHARACTERS OF THE PROXIMAL EPIPHYSIS

CONTENTS

		PAGE
(i)	Proximal Breadth	345
(ii)	Absolute and Relative Size of the Femoral Head	347
(iii)	Head-Bust Ratio	353
(iv)	Robusticity and Ellipticity of the Femoral Head	355
(v)	Capito-collar Axis or Bust Length	360
(vi)	Primary and Secondary Bust Ratios	363
(vii)	The Collar or Cervical Angle	366
(viii)	Indices of the Neck: (*a*) Ellipticity of the Neck	374
	(*b*) Secondary Index of the Neck	374
(ix)	The Lemotic Index	378
(x)	Epiphysial Ratio and Capito-bicondylar Index	382
(xi)	Concluding Remarks: Characters of the Proximal Epiphysis of the Hypothetical Protsimio-human	385

(i) Proximal Breadth.

We have already stated our objections to the proximal breadth when discussing (p. 233) Klaatsch's Proximal Breadth Index. It does not seem to us a satisfactory measure of the absolute size of the proximal epiphysis. It covers the area of two centres of ossification, and it is by no means easy to obtain a convention for its measurement which will insure the absence of marked personal equation. We have endeavoured to measure it from that point of the articular surface of the head which is furthest removed from the standard sagittal plane to that point of the surface of the great trochanter which is also furthest removed from the same plane, taking the maximum value of this length and not the projection of that maximum value on the standard horizontal plane. Possible variations of the proximal breadth are (i) the above projected value, (ii) the value obtained by placing the sliding bars of the calipers parallel to the shaft, (iii) the distance from the articular surface centre of the head to the point where the capito-collar axis if produced beyond the coaxial point cuts the surface of the great trochanter; and others can easily be imagined. All present considerable difficulty in practice. Before we proceed to discuss the absolute and relative size of the femoral head, we have thought it worth while to consider briefly the data we possess for the proximal breadth and ascertain what may be learnt from them with regard to the primates as a whole.

The table below scarcely needs summarising; we see that the proximal breadth of the primate femur has risen steadily from *Tarsius* and the *Galaginae* to Cromagnon Man, and then has fallen in Recent Man to more apelike dimensions. The modern Gibbon again appears as a possible degenerate (as far as size is concerned) from a larger fossil ancestor, more in keeping with other *Simiinae*. *Pithecanthropus erectus* is purely Recent Man-like. The reconstructed Grimaldi Type adult male appears as a transition

TABLE XXIX. *Proximal Breadth of Femur**.

	Group	Proximal Breadth			Group	Proximal Breadth	
Lemuroids	*Tarsiidae* (2) ...	8·55	Mean 16·42	Simiinae	Gibbon (2) ...	28·75	Mean 73·94
	Galaginae (6)...	10·0	Mean 10·07		Orang-utan (5)	60·3	
	Lorisinae (6) ...	11·65			Chimpanzee (2)	68·5	
	Chiromyrdae (2)	21·35	Mean 22·77		Gorilla (4) ...	♂ 103·3	93·01
	Indrisinae (8)	23·45			„ (3) ...	♀ 79·3	
	Lemurinae (18)	23·5			*Pithecanthropus erectus* (1) ...	92·0	
Cebidae	*Hapalinae* (16)	11·4	Mean 20·85	Primogenial Man	Neanderthal Type (7)	102·0	
	Nyctipithecinae (8)	12·7			Galley Hill (1) ...	100·1	
	Pithecia (2) ...	18·9			Cromagnon (5) ...	110	
	Lagothrix (2) ...	20·1			Grimaldi Type (2) ...	[107]	
	Cebus (6) ...	20·7			*Homo aurignacensis* (*Haus.*) (1)	86	
	Brachyurus (2)	22·4		Recent Man	17th century Londoners (73)	♂ 94·54	Mean. ♂ 86·04. ♀ 80·15
	Mycetes (2) ...	24·9			17th century Londoners (62)	♀ 85·32	
	Ateles (4) ...	35·7			Negroes (Various) ...	♂ [92·8]	
Simiadae	*Cercopithecus* (8)	26·4	Mean 35·03			♀ [85·3]	
	Semnopithecus (10)	33·2			Fuegians† ... (5)	♂ 80·20	
	Macacus (14)...	33·85			Fuegians† ... (4)	♀ 84·25	
	Cercocebus (4)	36·0			Viti Islanders‡ ... (24)	♂ 84·42	
	Cynocephalus (8)	45·7			Viti Islanders‡ ... (7)	♀ 78·86	
	Dryopithecus rhenanus	50 0			Caroline Islanders‡ .. (8)	♂ 82·50	
					Caroline Islanders‡ .. (4)	♀ 75·20	
					Australians‡ ... (5)	♂ 81·80	
					Australians‡ ... (3)	♀ 72·00	

* We have omitted from this table the measurements of Klaatsch on a few *selected* individuals of special races, as we consider that they have too little weight to be of value in interracial problems. We have introduced them in the table on p. 233, chiefly as a basis for the criticism of them provided in the fifth footnote p. 232.

† Hultkrantz, Bibl. 85.

‡ Prochownick, Bibl. 43. We find for our four Australian femora—2 ♂ 104·8, 2 ♀ 87·25—values far in excess of Prochownick's.

form between Cromagnon and Recent Man. Galley Hill is closer to the Neanderthal Type than to Recent Man; it is far removed from the relation to *Homo aurignacensis* (*Hauseri*), which Klaatsch overhastily assumed[1]. Modern Europeans and Negroes are nearer to the Neanderthal Type than any of the few primitive races for which we have material, while, according to Prochownick, the Australian femur for proximal breadth is anything but Neanderthaloid.

It might be convenient to make a division across the Lemuroids in the manner we have indicated in the table, in which case the subtypes would be *Galaginae* and

[1] Bibl. 103*bis*.

Indrisinae; otherwise the *Lorisinae* form the type, but not very closely. In the *Cebidae Cebus* is again type, and *Cercocebus* for the *Simiadae*. The Chimpanzee is nearest to type of the Greater Anthropoids. It is practically the type for the *Simiinae*, if *Dryopithecus* but not the Recent Gibbon be included. The inclusion of the latter transfers the type for this size character to the Orang. If it is safe to strike a mean on our six races of Recent Man we have ♂ 86·04, ♀ 80·15. The nearest race of our small series to type would then be the Fuegian, which for several more valid reasons we are disposed to consider as approaching Protoneoteric Man.

Of course any conclusions from the data for Recent Man as far as these are due to Hultkrantz and Prochownick depend upon those authors having taken the ill-defined proximal breadth approximately in our manner.

(ii) Absolute and Relative Size of the Femoral Head.

We now turn to the characters of the bust. In the first place the dimensions of the head must occupy our attention. They have peculiar interest whether treated absolutely or relatively, for they form one of the few generally admitted links between the apes and Primogenial Man of the Neanderthal Type. We may deal either with the vertical diameter[1] of the head as measuring as a rule its maximum dimension, or with the indices formed by the ratio of this diameter (i) to the length of the femur, (ii) to the bicondylar width[2], or (iii) to the length of the capito-collar axis. In the following table we classify according to absolute values and further according to the first two of these indices.

Now this table is remarkably suggestive and confirms the views to which we have already given expression—there is no close link between Primogenial Man and Primitive Modern Man. The European, ancient and modern, is closer in absolute size of femoral head to Primogenial Man than the Maori, the Negro, the Australian or the Andaman. If we turn from absolute size to the Capital Ratio—the proportion of head to size of femur—the apes are seen to be close in this proportion to Primogenial Man; the European separates both these groups from the primitive and uncivilised

[1] Although we do not put much faith for interracial purposes in the ellipticity of the head, we yet think it best to measure *both* vertical and horizontal diameters, and object to the vague taking of the "maximum diameter wherever found." The Secondary Neck Index, *i.e.* the ratio of minimum horizontal diameter of neck to horizontal diameter of head, is of interest, and the horizontal diameter of the head might be profitably compared with the length of the internal condyle. The vertical diameter of the head seems properly chosen for the capital index, and generally it is easier to determine than a non-orientated "maximum diameter."

[2] For femoral characters there is very considerable correlation between the vertical diameter of the head and the bicondylar width. For our London femora we have found (p. 194)

♂ R. ·750 ± ·024 (146); ♂ L. ·770 ± ·023 (146); ♀ R. ·584 ± ·048 (87); ♀ L. ·654 ± ·038 (104)

while Tamagnini and De Campos (Bibl. 118, p. 32) give for Portuguese femora in the case of the diameter of the head and the breadth of the distal articulation

♂ (R. + L.) ·63 ± ·03 (264); ♀ (R. + L.) ·63 ± ·03 (250),

confirming the high value, but not indicating our sexual difference. This is possibly due to their measuring the articulation only.

Table XXX. *Table of the Vertical Diameter of the Head and of the two Capital Indices.*

	Race	Vertical Diameter of the head		Capital Ratio $=100\frac{\text{Vert. Diameter}}{\text{Max. Length}}$		Capito-Bicondylar Ratio $=100\frac{\text{Vert. Diameter}}{\text{Bicondylar Width}}$	
Lemuroidea	*Tarsiidae*	3·7 (2)		5·75 (2)		53·6 (2)	
	Galaginae	4·7 (6)		7·8 (6)		54·35 (6)	
	Lorisinae	7·2 (6)	Mean 7·88	9·2 (6)	Mean 7·74	59·5 (6)	Mean 57·38
	Chiromyrdae	10·3 (2)		8·3 (2)		55·35 (2)	
	Indrisinae	10·6 (8)		7·1 (8)		61·0 (8)	
	Lemurinae	10·8 (18)		8·3 (18)		60·5 (18)	
Cebidae	*Hapalinae*	5·6 (16)		8·5 (16)		55·4 (16)	
	Nyctipithecinae	6·9 (8)		7·8 (8)		53·2 (8)	
	Pithecia	9·3 (2)		7·2 (2)		55·35 (2)	
	Cebus	10·4 (6)	Mean 10·91	8·7 (6)	Mean 8·38	55·0 (6)	Mean 54·76
	Lagothrix	11·25 (2)		10·05 (2)		51·15 (2)	
	Brachyurus	11·65 (2)		7·55 (2)		58·55 (2)	
	Mycetes	13·5 (2)		8·9 (2)		52·55 (2)	
	Ateles	18·7 (4)		8·35 (4)		56·9 (4)	
Simiadae	*Cercopithecus*	12·7 (8)		9·0 (8)		57·1 (8)	
	Macacus	16·4 (14)		9·5 (14)		56·8 (14)	
	Cercocebus	16·9 (4)	Mean 16·84	7·7 (4)	Mean 8·80	57·25 (4)	Mean 57·57
	Semnopithecus	17·0 (10)		8·5 (10)		58·6 (10)	
	Cynocephalus	21·2 (8)		9·3 (8)		58·1 (8)	
	Dryopithecus rhenanus	24·0 (1)		8·4 (1)		58·4 (1)	
Simiinae	Gorilla	47·9 (7)		13·5 (7)		53·9 (7)	
	Chimpanzee	34·6 (3)	Mean 37·50	11·8 (3)	Mean 12·67	53·1 (3)	Mean 55·70
	Orang-utan	30·0 (5)		12·7 (5)		60·1 (5)	
	Gibbon	17·6 (3)		8·6 (3)		58·7 (3)	
	Pithecanthropus erectus	45·0 (1)		9·89 (1)		57·7 (1)	
Primogenial Man	Spy	55·8 (1)		13·0 (1)		59·6 (1)	
	,, [Klaatsch	53·0 (2)		12·8 (2)		58·9 (2)]	
	Neanderthal	54·0 (1)	Mean Neanderthal (6) 52·3*	12·1 (1)	Mean Neanderthal (6) 12·4*	60·3 (1)	Mean Neanderthal (6) 59·7*
	,, [Klaatsch	53·0 (2)		11·9 (2)		60·3 (2)]	
	La Chapelle-aux-Saints	51·6 (1)		12·0 (1)		61·4? (1)	
	Galley Hill	49·2 (1)		11·6 (1)		55·9?? (1)	
	Homo mousteriensis (*Hauseri*)	47·7 (1)		12·4 (1)		57·3 (1)	
	Homo aurignacensis (*Hauseri*)	41·0 (1)		9·6 (1)		54·7 (1)	
	Cromagnon	54·6 (5)		10·2 (5)†		57·6 (5)	
	Grimaldi Type	52·0 (2)		10·3 (2)		56·0 (2)	

Recent Man	♂		♀		♂		♀		♂		♀	
Bajuvars from Row Graves	50·1	(18)	44·0	(8)	10·6	(18)	10·3	(8)	61·9	(10)	62·2	(11)
Rothwell, English	49·14	(174)	42·46	(105)	10·7	(174)	10·2	(101)	{64·3	(160)}	{62·9	(88)}
Ancient Persians (Anau)	49·0	(2)	—		10·3	(2)	—		56·0	(2)	—	
Swabians and Alemanns from Row Graves	48·3	(10)	41·5	(4)	10·3	(10)	10·4	(4)	60·3	(6)	58·4	(2)
Romano-British	47·9	(7)	—		10·5	(6)	—		59·7	(3)	—	
Modern British	47·6	(39)	—		10·3	(39)	—		58·8	(39)	—	
Modern Swiss	47·1 (22)				10·4 (20)				58·2 (22)			
Modern French	47·0	(62)	41·0	(38)	10·6	(60)	10·2	(40)	—		—	
Hindoos	47·0	(6)	36·5	(2)	9·8	(6)	9·1	(2)	58·3	(6)	54·9	(2)
17th century Londoners	46·91	(416)	40·94	(319)	10·49	(390)	10·03	(296)	59·02	(289)	58·22	(194)
Neolithic Man (Châlons-sur-Marne)	46·5	(23)	40·8	(10)	10·5	(23)	9·95	(10)	—		—	
North American Europeans	46·5	(200)	41·3	(200)	[10·4	?]	[9·9	?]	—		—	
Portuguese	46·33	(264)	40·19	(250)	10·3	(134)	9·9	(126)	{61·7	(264)}	{61·5	(250)}
Fuegians	46·3 (10)				10·8 (10)				57·2 (10)			
Neolithic Man (Montigny Esbly)	45·0	(10)	40·0	(4)	10·2	(10)	9·9	(4)	—		—	
Maori	44·9	(10)	41·4	(7)	10·1	(10)	10·1	(7)	56·2	(7)	61·0	(7)
Negroes	44·9	(10)	40·0	(3)	9·7	(10)	9·2	(3)	57·1	(10)	55·7	(3)
Australians‡	44·1	(12)	33·5	(2)	9·4	(12)	8·2	(2)	56·9	(12)	55·2	(2)
Neolithic Man (Chamblands)	44·0	(20)	40·5	(18)	10·5	(20)	10·2	(18)	—		—	
Neolithic Swiss Dwarfs	—		38·0	(3)	—		10·1	(3)	—		56·1	(3)
Andamans	36·6	(8)	35·1	(4)	9·6	(8)	9·7	(4)	54·4	(8)	57·0	(3)

* In the Tables throughout this Chapter the mean Neanderthaloid values are taken from Table III in Chapter X and are *not* the mean of the four Neanderthaloid femora provided in the first columns. They include in each case what measurements were available on casts and photographs of Spy, Neanderthal, *H. mousteriensis* (*Hauseri*), *La Chapelle-aux-Saints* and *La Ferrassie*.

† Based on mean vertical diameter for 5 femora given by Verneau (Bibl. No. 94 *quater*, Tom II, Fasc. 1, p. 108), and on the maximum length as deduced from the oblique length of 13 femora given by Rodriguez we find 10·1 instead of 10·2. See Table III in Chapter X.

‡ We find for our own *four* Australian femora:

Vertical Diameter of Head ♂ 49·05, ♀ 42·35; Capital Ratio ♂ 10·85, ♀ 10·6; Capito-Bicondylar Ratio ♂ 61·4, ♀ 60·0; results wholly out of keeping with those of Hepburn in the above table.

man. In the case of the ratio of head to bi-epicondylar width the European is closest to Primogenial Man[1], and separates the latter from Primitive Man, and the still more emphasised distal epiphysis of the apes. In fact a consideration of the head in no case suggests as an evolutionary order: Apes, Primogenial Man, Primitive Modern Man, Modern Civilised Man. This table gives no encouragement to the view that the Australian as far as his femur is concerned is in any way akin to Primogenial Man. The Trinil femur as far as its head is concerned is widely differentiated from those of the apes and Primogenial Man; it might in this respect well be the femur of a Melanesian or a Negro.

Turning now to the Primates as a whole we note a steady increase in absolute size of head from Lemuroids to Man although the progress was much accelerated in the *Simiadae* as compared with the *Cebidae*. With Man the progress in size continued through Neanderthal to Cromagnon Type, but after that declined considerably for reasons which are at present unrecognised. Some light, however, may be thrown on the matter if we pass from absolute to relative size, which is always more satisfactory. Here in the Capital Ratio we see that while *Cebidae* and *Simiadae* increased somewhat on relative size of head on the Lemuroids, the main advance was made with the Greater Anthropoids and Primogenial Man of the Neanderthal Type—the Gibbon, fossil and recent, having much the same relative size of head as *Ateles* in the *Cebidae* and *Semnopithecus* in the *Simiadae*, *i.e.* it had not advanced in this respect beyond the Lesser Ape mean values. The change to the Recent Man value came with Cromagnon Man. Thus Cromagnon was not on the summit as for absolute size of head, but already on the decline towards Lesser Ape values. It is another case of "scission of the Primates" in which modern man stands between the Lesser Apes and the Greater Anthropoids.

If we turn to the Capito-bicondylar Ratio, we find on the whole very little variation throughout the Primates; the mean value for the Lemuroids can easily be paralleled from existing races of man. The bicondylar width increases relatively to the head from Lemuroids to *Cebidae*, and less markedly but uniformly from Lemuroids through *Simiadae* to the Anthropoids. But with Primogenial Man we note a rise of a marked kind, and Recent Man follows with a slight fall which places him in this respect on the same level as fossil and recent Gibbons. On the whole this index is wonderfully persistent in the Primates and there is no racial human value which does not fall within the range of values exhibited by the Lemuroid genera. It will be seen that the determination of type forms in the various families for these three characters is by no means clear. On the whole the *Lorisinae* seem to be nearest to type in the Lemuroids, *Cebus* in *Cebidae*, and *Cercocebus* in the *Simiadae*. In the case of the Greater Anthropoids, honours for both 1st and 2nd places are shared equally, but the total deviation from type of the Chimpanzee is only 4·37 points, while those of the Orang and Gorilla are 12·20 and 13·03 respectively. Hence the Chimpanzee may be considered nearest to type.

[1] We must dismiss the Rothwell English and Portuguese from this comparison for in both cases the articulation and not the bi-epicondylar breadth has been measured.

Closely allied to the Capital Ratio is the so-called Robusticity of the Head which is given by 100 × sum of the head diameters/maximum length. For practical purposes this is twice or still more accurately $\left(1+\frac{E}{100}\right)$ times the Capital Ratio, where E is the ellipticity of the head. Some writers use the circumference of the head in place of the sum of the two diameters. This measure of the robusticity is very nearly π times the former measure and 2π times the Capital Index. Rodriguez has given very complete returns for both the robusticity of the head and for the ellipticity. Unfortunately he combines male and female, and uses the oblique instead of the maximum length. Hence for comparison with our data we should have to combine our sexes after reducing our indices to oblique length. It seemed better accordingly not to mix the sexes but to give Rodriguez's data for these characters in a separate table, which will stand a fair comparison with the table just given. These results as well as those on p. 361 for the Capito-collar length are based on the assumption that the following indices: Robusticity of Head ($I_{(f+g)/d}$), Ellipticity of Head ($I_{g/f}$) and the Capito-collar Index or Secondary Bust Ratio ($I_{t/d}$), are approximately the same for the two sexes, and that the differentiated absolute lengths of the two sexes may be found from them by using the Oblique Length (d) for the femur which Rodriguez does give for both sexes. In the case of the Capital Ratio the reconstructed Vertical Diameter of the Head (f) was divided by the Maximum Length (a) reconstructed from the Oblique Length (d) by means of the results given on our p. 226.

The formulae involved are the following:

$$\text{Vertical Diameter of Head } (f) = \frac{I_{(f+g)/d}}{100 + I_{g/f}}\, d,$$

$$\text{Capito-Collar Length } (t) = \frac{I_{t/d}}{100}\, d,$$

$$\text{Capital Ratio} = 100 f/a,$$

$$\text{Head-Bust Ratio}^1 = \frac{100}{1 + I_{g/f}/100}\, \frac{I_{(f+g)/d}}{I_{t/d}}.$$

In the case of the Capital Ratio the very slight differences between the values for the two sexes arise solely from the different corrections to be made when the Oblique Length (d) is transformed to the Maximum Length (a). In deducing results from this table the reader must be cautioned to regard the smallness of a considerable number of the series. Further, especially in the case of ancient bones, the larger are more likely to survive, and many osteometrical investigators appear to neglect the collection or the measurement of fragments, which usually belong to the less robust femora. We have little doubt that this is one of the factors which have contributed to Parsons' English femoral head rivalling in absolute size that of the Patagonians.

For classificatory purposes we propose to introduce the following terms as convenient:

[1] Used to provide values from Rodriguez's data for the Head-Bust Ratio column in Table XXXII of p. 354.

TABLE XXXI. *Vertical Diameter of Head and Capital Ratio of the Femur of Various Races deduced from Rodriguez's Data.*

Race	No. ♂ + ♀	Vertical Diameter ♂	Vertical Diameter ♀	Race	No. ♂ + ♀	Capital Ratio ♂	Capital Ratio ♀
Spy	1	54·5	—	Spy	1	12·7	—
Cromagnon	13	54·4	—	Cromagnon	13	10·9	—
Gauls and Romano-Gauls	78	49·3	44·5	Laplanders	6	11·1	—
Patagonians	101	49·2	44·1	Japanese	92	11·0	11·0
Franks and Burgundians	30	48·8	44·9	Turks	18	10·9	—
Modern Germans ...	18	48·6	?	Chinese	6	10 9	10·9
Mediterranean Race ...	32	48·3	44·2	Eskimo	13	10·7	10·7
Negritos	42	47·6	36·4	Gauls and Romano-Gauls	78	10·7	10·6
Fossil Grimaldi Negroes*	3	—	43·5	Ancient Slavs	43	10·7	10 7
Mediaeval French ...	183	47·5	43·8	Peruvians	75	10·7	10·7
Modern French	69	47·4	45·7	Ancient Bolivians ...	51	10·6	10·5
Ancient Slavs	43	47·3	43 9	Patagonians	101	10·6	10·6
Turks	18	47·1	—	Fuegians	12	10·6	10·5
Merovingians	40	46·4	42·8	Franks and Burgundians	30	10·6	10·5
Neolithic Europeans ...	240	46·0	42·1	Mediterranean Race ...	32	10·6	10·6
Fuegians	12	45·8	42·6	Ancient Mexicans ...	22	10·5	10·5
Eskimo	13	45·7	44·0	Mediaeval French ...	183	10·5	10·5
Phoenicians and Carthaginians	16	45·5	41·8	Modern French	69	10 5	10·4
				Modern Germans ...	18	10·5	10·5
Polynesians	18	45·5	42 4	Ancient Equatorial Indians	126	10·5	10·4
Berbers and Guanches ...	94	45·5	42·7	Europeans, Bronze Age ...	46	10·4	10·4
Negroes of Guinea ...	16	45·5	—	Basques	35	10·4	—
Japanese	92	45·5	41·7	Phoenicians and Carthaginians	16	10·4	10 3
Chinese	6	45·3	44·1				
Europeans, Bronze Age ...	46	45·3	39·9	Merovingians	—	10·4	—
Aino	8	45·2	40·6	Aino	8	10·4	10·3
Laplanders	6	44·7	—	Indo-Chinese	16	10·3	10·2
Negroes (*? locus*) ...	48	44·5	41·1	Indonesians	14	10·3	10·3
Basques	35	44·5	—	Ancient Venezuelians ...	43	10·3	10·3
Canary Islanders ...	287	44·3	40·5	Neolithic Europeans ...	240	10·3	10·3
Ancient Mexicans ...	22	44·3	41·1	Californian Indians ...	122	10·2	10·2
Indonesians	14	44·3	42·4	Malays	118	10·1	10·1
Mozambique	13	44·3	41·3	Polynesians	18	10·1	10·1
Peruvians	75	44·1	41·5	Berbers and Guanches ...	94	10·1	10·1
Ancient Venezuelians ...	43	44·1	41·0	Ancient Egyptians ...	22	10·0	10·0
Ancient Egyptians ...	22	44·0	42·5	Negroes of Guinea ...	16	10·0	—
Melanesians	80	43·7	40·5	Fossil Grimaldi Negroes*	3	—	10·0
Indo-Chinese	16	43·5	42·2	Negritos	42	9·9	9·8
Ancient Bolivians ...	51	43·5	39·5	Negroes (*? locus*) ...	48	9·9	9·8
Californian Indians ...	122	43·2	40·1	Mozambique	13	9·8	9·8
Veddahs	2	43·0	—	Canary Islanders ...	287	9·9	9 8
Malays	118	42·9	39·1	Melanesians	80	9·8	9 7
Ancient Equatorial Indians	126	42·9	39·1	Veddahs	2	9·7	—
Congolese	20	42·8	38·6	Hindoos	18	9·7	9·7
Hindoos	18	40·7	40·1	Congolese	20	9·5	9·5

* As to the Grimaldi type see our Chapter X. We do not know where these *three* apparently all *female* femora are deposited.

First with regard to the absolute size of head:

Femora with Vertical Diameters of Head.

Over	50 mm.	are *hyperdolichocratic*,
Between	47·0 and 50 mm.	are *dolichocratic*,
Between	45·0 and 47·0 mm.	are *mesocratic*,
Between	43·0 and 45·0 mm.	are *brachycratic*,
Below	43·0 mm.	are *hypobrachycratic*.

Primogenial Man falls into the first class; transition to the dolichocratic may be found in the Galley Hill femur, to which group belong prehistoric, early historic and most modern Europeans. Transition to the mesocratic group may be found in our 17th century Londoners; in this group are found also the Eskimo, Fuegians, Guanches and chief Asiatics as well. American Indians and most of the Negroes tend to be brachycratic, passing, however, into both mesocratic and hypobrachycratic classes. Malays, Veddahs and according to the longer series Hindoos are hypobrachycratic. It is noteworthy that the Negritos (possibly also the Grimaldi negroid femora, if really female) are differentiated from the Negroes of Africa and are dolichocratic. In the same group also are to be found the Patagonians widely separated from the rest of the South Americans. The Australians verge on and the Andamans show marked hypobrachycracy, to which class belong all the anthropoids (except the gorilla) and the lesser apes.

Secondly with regard to the size of the femoral head relative to the maximum length:

Femora with Capital Ratio.

Over	11·5 mm.	are *hyperdolichocephalic*,
Between	10·5 and 11·5 mm.	are *dolichocephalic*,
Between	10·0 and 10·5 mm.	are *mesocephalic*,
Between	9·5 and 10 mm.	are *brachycephalic*,
Below	9·5 mm.	are *hypobrachycephalic*.

Again we see Primogenial Man of the Neanderthal Type in the highest class. He had not only an absolutely large femoral head, but he had a short femoral length. Galley Hill Man suggests again a transitional form. Cromagnon is merely dolichocephalic; although high up in the class, it is surpassed by Laplanders and Japanese and equalled by the Chinese. In fact the big head of the Cromagnon Type was accompanied by an all round big femur. Patagonians, Fuegians, Eskimo, some of the South American Indians and Parsons' Rothwell English (doubtful?) are also dolichocephalic as to femur. At the bottom of the class and passing into the mesocephalic are most modern European races, and many of their historic and pre-historic forerunners. Aino, Indo-Chinese, Malays, and Polynesians and Maori are found towards the bottom of the mesocephalic group, where the Negroes, Negritos and Grimaldi negroid fossil bones form a transition group to the brachycephalic category which contains Veddahs, Andamans, and Hindoos also. The only truly hypo-

brachycephalic race being found in the Australians, who herein approach lesser apes and Lemuroids, which belong to this group.

It will be seen that in the analysis of the femoral head made on the basis of these characters there is no resemblance of the Australian femur to that of Primogenial Man nor indeed of the latter to any primitive type of modern man. The European stands, if at much distance from the former, between the two. Absolutely the same point is brought out if we consider the Capito-bicondylar Index; here there is very little difference between Neanderthal Man and the modern European, but both stand markedly apart from Negro, Fuegian, Maori, Australian and Andaman, in whose femora the distal epiphysis is large as compared to the size of the femoral head.

(iii) Head-Bust Ratio.

We may take as our last relative measure of the femoral head its relation to the size of the bust as a whole, *i.e.* the Head-Bust Ratio which is defined as 100 Vertical Diameter of Head divided by the Bust or Capito-collar Axis.

Here again the accompanying table shows marked evidence of the want of an evolutionary serial order for Man. Primogenial Man of the Neanderthal Type, with whose femur is associated in this as in several other features the Galley Hill femur, heads the list. In Primogenial Man of the Neanderthal Type the diameter of the head is something like 72 °/₀ of the bust length. In modern European man it is only 61 °/₀. The Cromagnon Type is intermediate, about 64 °/₀, which is a value much that of modern Asiatics. Mediaeval and prehistoric Europeans lie between the Cromagnon and modern values. At the bottom of the series lie various "fringe" races, Laplanders, Basques and Veddahs; still lower below the human series lie the apes, although the Gibbon and Orang cross the lowest values of the human series. Again we cannot emphasise any obvious evolutionary order—Modern Man separates the apes from Primogenial Man and forms indeed by his range of values an almost continuous series from the one to the other.

Now if we examine the table from the standpoint of broad primate groups we have for the means:

Lemuroidea,	mean of 6 genera ...	76·73
Cebidae,	mean of 8 genera ...	66·81
Simiadae,	mean of 5 genera ...	70·04
Simiinae,	mean of 4 genera ...	59·48
Primogenial Man,	Neanderthal Type	72·7
,,	,, Galley Hill ...	68·3
,,	,, Cromagnon Type	64·2
Recent Man,	mean of 33 Races ...	62·36.

If we suppose the mean of each group to be nearest its primitive form, then *Tarsius* (76·35) is nearest to that form, and it has spread out to the *Chiromyrdae* and *Lorisinae* on the one hand with large heads relative to the busts and to the *Indrisinae* and *Lemurinae* on the other with small heads relative to the busts. In the *Cebidae*

regarding the Head-Bust Ratio only the primitive form lies between *Brachyurus* (67·35) and *Pithecia* (65·25) and the development has been to the *Hapalinae* with relatively large heads on the one hand and to *Ateles* with a relatively small head (55·9) on the other. In this extreme Head-Bust Ratio we must compare *Dryopithecus rhenanus*

TABLE XXXII. *Table of the Head-Bust Ratio* = 100 *Vertical Diameter of Head/Bust Length.*

	Race	Head-Bust Ratio ♂	Head-Bust Ratio ♀	Mean
Lemuroids	*Chiromyrdae*	84·1 (2)		76·73
	Lorisinae	83·8 (6)		
	Galaginae	78·0 (6)		
	Tarsiidae	76·35 (2)		
	Lemurinae	70·4 (18)		
	Indrisinae	67·75 (8)		
Cebidae	*Hapalinae*	76·7 (16)		66·81
	Nyctipithecinae	74·0 (8)		
	Cebus	69·2 (6)		
	Brachyurus	67·35 (2)		
	Pithecia	65·25 (2)		
	Lagothrix	63·7 (2)		
	Mycetes	62·35 (2)		
	Ateles	55·9 (4)		
Simiadae	*Cercopithecus*	75·4 (8)		70·04
	Semnopithecus	73·5 (10)		
	Macacus	70·0 (14)		
	Cynocephalus	66·8 (8)		
	Cercocebus	64·5 (4)		
Simiinae	Gorilla	55·9 (51)		59·48
	Chimpanzee	59·6 (25)		
	Orang-utan	60·5 (6)		
	Gibbon	61·9 (24)		
	Dryopithecus rhenanus	55·3 (1)		
	Pithecanthropus erectus	60·8 (1)		
Neanderthal Type	Spy	73·2 (1)		72·7
	Neanderthal	83·7 (1)		
	La Chapelle-aux-Saints	62·5 (1)		
	Galley Hill	68·3 (1)		
	Homo mousteriensis (*Hauseri*)	71·2 (1)		
	Homo aurignacensis (*Hauseri*)	59·4 (1)		

Race	Head-Bust Ratio ♂	Head-Bust Ratio ♀
Rothwell English	{74·7 (174)}	{75·3 (126)}
Portuguese	{71·7 (134)}	{71·3 (126)}
Chinese	67·1 (6)	
Malays	65·5 (118)	
Turks	64·9 (18)	
Phoenicians and Carthaginians	64·7 (16)	
Negritos	64·2 (42)	
Cromagnon	64·2 (13)	
Patagonians	63·9 (101)	
Melanesians	63·8 (80)	
Polynesians	63·6 (18)	
Gauls and Gallo-Romans	63·6 (78)	
Japanese	63·6 (92)	
Neolithic Swiss Dwarfs	63·5 (3)	
Franks, Burgundians and Merovingians	63·0 (70)	
Mediaeval French	63·5 (183)	
Ancient Slavs	62·8 (43)	
Indo-Chinese	62·7 (16)	
Fuegians	62·4 (12)	
Bronze Age Europeans	62·3 (46)	
French Neolithics	61·9 (240)	
Berbers and Guanches	61·7 (94)	
Ancient Egyptians	61·5 (22)	
Negroes (Various)	61·5 (97)	
17th century Londoners	61·32 (411)	60·70 (306)
Hindoos	61·3 (18)	
Aino	61·2 (8)	
Ancient Equatorial and S. American Indians	61·1 (452)	
Modern Germans	60·9 (18)	
Modern French	60·8 (69)	
Australians (Pearson)	60·6 (2)	77·7 (!) (2)
Eskimo	60·4 (13)	
Canary Islanders	60·3 (287)	
Laplanders	60·2 (6)	
Basques	59·9 (35)	
Veddahs	57·9 (2)	

N.B. In this Table we have had chiefly to depend on Rodriguez's measurements, as he is the only author who has measured the length of the Capito-collar Axis or Bust as we have done. Parsons for the Rothwell English, and Tamagnini and de Campos for the Portuguese, who have followed him, are dealing with a wholly different bust length.

(55·3) and not the Gibbon (61·9) with *Ateles*. In the *Simiinae* it is the Chimpanzee (59·6) which approaches closest to the Anthropoid mean, and after that the Orang. The extreme developments are on the one side the Gorilla (55·9) and on the other the Gibbon (61·9). This result is only reached, however, by pooling a large number of measurements from various sources, and we prefer our own results which give for Gorilla 60·1 and for Gibbon 58·2, thus inverting the above order and placing the Gibbon nearer, as we think it should be, to *Dryopithecus rhenanus*. There is probably not much difference in the Anthropoids for the Head-Bust Ratio. Turning to Man we see that for Recent Man the mean is almost exactly that of the Fuegians (62·4), which may be suggested therefore as the primitive type, the protoneoteric type. From this the evolution has been to the relatively small heads of the Basques on one side and to the relatively large heads of the Chinese and Malays on the other. Primogenial Man is by no means easy to fit into the general scheme. Galley Hill is here as in a number of other characters intermediate between Neanderthal and Cromagnon, and the series Neanderthal Type, Galley Hill, Cromagnon Type, Recent Man is a very satisfactory one. But Neanderthal stands at the opposite extreme to the Anthropoids. The succession: *Lemuroidea*, *Simiadae*, *Simiinae* is quite good, but Primogenial Man carries us back to something between *Simiinae* and *Simiadae* if not in the case of the Neanderthal Type to something between the latter and the Lemuroids. It is another case of the scission of the primates or the reversion of Recent Man from Primogenial Man to more apelike proportions.

(iv) Robusticity and Ellipticity of the Femoral Head.

(*a*) The Robusticity of the Head is measured by the ratio of the sum of the vertical and horizontal diameters of the head to the oblique length, this ratio as usual being multiplied by 100. The accompanying table summarised in the following means indicates a marked serial order of development:

Lemuroidea (42 femora) ...	15·62
Cebidae (42 femora)	16·88
Simiadae (44 femora)	17·59
Greater Anthropoids (3 genera)	24·87
Neanderthal Type Man ...	25·0
Galley Hill Man	23·3?
Cromagnon Type Man ...	21·79
Recent Man (71 racial groups)	20·72
17th century Londoners ...	20·60.

To these we may add for comparison:

Dryopithecus rhenanus ...	16·7
Gibbon	16·8
Ateles	16·7.

These results can leave no doubt in our mind that the Greater Anthropoids are closer by far in this character to Primogenial Man than the Gibbons, fossil or recent.

Indeed the femur alone would provide small evidence that the gibbon is properly included in the *Simiinae*. We have indeed repeatedly to leave him on one side in taking averages for this group. His nearest resemblance lies in this as in a variety of other characters to *Ateles*. This may be due to the development enforced by a common method of life, but it also suggests that the ancestor of the gibbon is rather to be sought in a common ancestor of *Cebidae* and *Simiadae* than in a common ancestor of *Simiadae* and *Simiinae*. It is certainly difficult to believe that the troglodytic femur of Primogenial Man—and we may almost give that of Recent Man the same title—should have sprung from a gibbon-like rather than a chimpanzee-like ancestor. As is so frequently the case the Neanderthal Type overshot the mark, and we have a descent possibly through a Galley Hill Type, almost certainly through the Cromagnon Type to the less but still great robusticity of Recent Man, for whom our 17th century Londoners will stand very well as type.

The highest robusticity in Recent Man is exhibited by the Oriental Type of the Asiatics and by certain fringe races. Modern European races follow; they seem to be more robust than their prehistoric and mediaeval forbears. Lastly we have modern primitive races from Polynesians and Maori to Veddahs, Australians and Andamans at the extreme. In this character as in several others the relation which has been suggested between Australian and Primogenial Man of Type I certainly finds no justification. We may classify for this rather important femoral index as follows:

Hypereurostic: all values 24 and above,
Macroeurostic: all values 21·5 and under 24,
Mesoeurostic: all values 20·5 and under 21·5,
Microeurostic: all values 19·5 and under 20·5,
Hypoeurostic: all values under 19·5.

Only the Greater Anthropoids and Primogenial Man provide hypereurostic races; macroeurostic are Lapps, Eskimos and Fuegians, Japanese and Chinese. Modern and Ancient Europeans are chiefly mesoeurostic; Malays, Polynesians, Melanesians, Maori and Negroes are microeurostic, while the hypoeurostic class embraces Veddahs, Australians and Andamans. Thus the most primitive of existing races have—contrary, perhaps, to expectation—the least robust femora.

(*b*) The Ellipticity of the Head is measured by 100 × the ratio of Horizontal to Vertical Diameter of Head. Here the summary of means gives us:

Lemuroidea (42 femora) ...	102·27
Cebidae (42 femora)	100·21
Simiadae (44 femora) ...	99·45
Dryopithecus rhenanus (1) ...	99·6
Simiinae (including Gibbon)	100·03
Neanderthal Type (6) ...	98·4
Cromagnon Type (13) ...	100·0
Recent Man (47 racial groups)	99·35
17th century Londoners ...	99·0.

Table XXXIII. *Robusticity and Ellipticity of Femoral Head.*

	Race	Robusticity of the Head: Value ♂ + ♀	Robusticity of the Head: Source	Race	Ellipticity of the Head: Value ♂ + ♀	Ellipticity of the Head: Source
Lemuroids	*Tarsiidae*	12·0 (2)	Present Authors	*Tarsiidae*	108·1 (2)	Present Authors
	Indrisinae	14·2 (8)		*Chiromyrdae*	104·35 (2)	
	Galaginae	15·8 (6)		*Galaginae*	103·6 (6)	
	Lemurinae	16·5 (18)		*Indrisinae*	100·2 (8)	
	Chiromyrdae	16·9 (2)		*Lemurinae*	99·2 (18)	
	Lorisinae	18·3 (6) Mean 15·62		*Lorisinae*	98·2 (6) Mean 102·27	
Cebidae	*Pithecia*	14·4 (2)	Present Authors	*Lagothrix*	101·8 (2)	Present Authors
	Brachyurus	15·05 (2)		*Nyctipithecinae*	100·7 (8)	
	Nyctipithecinae	16·3 (8)		*Cebus*	100·2 (6)	
	Ateles	16·7 (4)		*Hapalinae*	100·1 (16)	
	Hapalinae	17·0 (16)		*Pithecia*	100·0 (2)	
	Cebus	17·5 (6)		*Ateles*	100·0 (4)	
	Mycetes	17·75 (2)		*Brachyurus*	99·55 (2)	
	Lagothrix	20·35 (2) Mean 16·88		*Mycetes*	99·3 (2) Mean 100·21	
Simiadae	*Cercocebus*	15·55 (4)	Present Authors	*Cercocebus*	100·6 (4)	Present Authors
	Semnopithecus	17·1 (10)		*Semnopithecus*	99·35 (10)	
	Cercopithecus	17·9 (8)		*Macacus*	99·3 (14)	
	Cynocephalus	18·5 (8)		*Cercopithecus*	99·1 (8)	
	Macacus	18·9 (14) Mean 17·59		*Cynocephalus*	98·9 (8) Mean 99·45	
	Dryopithecus rhenanus ...	16·7 (1)	Cast	*Dryopithecus rhenanus*	99·6 (1)	
Simiinae	Orang-utan	26·4 (8)	Various	Gorilla	100·0 (5)	Present Authors Various ,,
	Gorilla	25·6 (48)	,,	Gibbon	100·7 (2)	
	Chimpanzee	22·6 (27)	,,	Chimpanzee	99·9 (25)	
	Gibbon	16·8 (24) Mean 24·87	,,	Orang-utan	99·5 (6) Mean 100·03	
	Pithecanthropus erectus ...	19·7 (1)	Dubois	*Pithecanthropus erectus*	97·8 (1)	Dubois

Robusticity and Ellipticity of Femoral Head (continued).

	Race	Robusticity of the Head: Value ♂	Robusticity of the Head: Value ♀	Robusticity of the Head: Source	Race	Ellipticity of the Head: Value ♂	Ellipticity of the Head: Value ♀	Ellipticity of the Head: Source
Primogenial Man	Spy	25·9 (1)	Mean Neanderthal (6) 25·0	Cast	*Homo aurignacensis* (*Hauseri*)	104·9 (?) (1)		Klaatsch
	Homo mousteriensis (*Hauseri*)	25·2 (1)		,,	Cromagnon	100·00 (13)		Rodriguez
	La Chapelle-aux-Saints	24·8 (1)		Photographs etc.	*Homo mousteriensis* (*Hauseri*)	99·4 (1)	Mean Neanderthal (6) 98·4	Cast
	Neanderthal	24·1 (1)		Cast	La Chapelle-aux-Saints	99·7 (1)		Photographs etc.
	Galley Hill	23·3 (1)		,,	Spy	98·6 (1)		Cast
	Cromagnon	21·79 (13)		Rodriguez	Neanderthal	97·8 (1)		,,
	Homo aurignacensis (*Hauseri*)	19·9 (1)		Klaatsch	Galley Hill	(?)		—
Recent Man	Laplanders I	22·19 (6)		Rodriguez	Fossil Negroid Grimaldi	102·83 (3)		Rodriguez
	,, II	[19·94 (4)]		Hepburn	Aino	100·99 (8)		,,
	Japanese	22·02 (92)		Rodriguez	Eskimo	100·39 (13)		,,
	Chinese	21·93 (6)		,,	Negroes I	100·13 (12)		Bumüller
	Turks	21·94 (18)		,,	Melanesians	100·00 (80)		Rodriguez
	Fuegians I	21·79 (10)		Hultkrantz	Maori	100·00 (4)		Mollison
	,, II	21·20 (12)		Rodriguez	Polynesians	99·96 (18)		Rodriguez
	Australians	21·7 (2)	21·3 (2)	Pearson and Bell	Indonesians	99·93 (14)		,,
	Eskimo I	21·55 (13)		,,	Negritos	99·89 (42)		,,
	,, II	20·01 (4)		Hepburn	Berbers and Guanches	99·86 (94)		,,
	Rothwell English	[21·49 (174)	20·28 (103)]	Parsons	Indians	99·80 (48)	100·20 (33)	Antony and Rivet
	Modern Bolognese	[21·46 (24)	21·19 (24)]	Zanolli	Malays	99·78 (118)		Rodriguez
	Ancient Slavs	21·32 (43)		Rodriguez	Negroes II	99·78 (97)		,,
	Patagonians	21·22 (101)		,,	Ancient Equatorial and South American Indians	99·75 (452)		,,
	Gauls and Romano-Gauls	21·24 (78)		,,				
	Modern French I	[21·21 (62)	20·60 (38)]	Various	Fuegians I	99·72 (12)		,,
	,, ,, II	20·93 (69)		Rodriguez	,, II	99·15 (10)		Hultkrantz
	Modern Germans	21·09 (18)		,,	Modern Germans	99·53 (18)		Rodriguez
	Romano-British	[21·08 (6)]		Hepburn	Men of Bronze Age, France	99·50 (46)		,,
	Franks and Burgundians	21·07 (30)		Rodriguez	Ancient Egyptians	99·43 (22)		,,
	Neolithic Swiss (Chamblands)	[21·06 (15)	20·39 (9)]	Schenk	Canary Islanders	99·43 (287)		,,
	17th century Londoners	21·02 (335)	20·17 (246)	Authors	Modern French	99·36 (69)		,,
	Mediaeval French	21·01 (183)		Rodriguez	Chinese	99·36 (6)		,,
	Ancient South and Equatorial American Indians	20·97 (452)		,,	Indo-Chinese	99·36 (16)		,,
					Turks	99·36 (18)		,,
	Neolithic Man, Châlons-sur-Marne	[20·97 (23)	19·98 (9)]	Manouvrier	Patagonians	99·36 (101)		,,

Race	Robusticity of the Head		Race	Ellipticity of the Head	
	Value ♂ ♀	Source		Value ♂ ♀	Source
Ainos	20·93 (8)	Rodriguez	Phoenicians and Carthaginians	99·33 (16)	Rodriguez
Men of Bronze Age	20·92 (46)	,,	Hindoos	99·31 (18)	,,
Merovingians	20·89 (40)	,,	Modern Bolognese	99·30 (24) 99·00 (24)	Zanolli
Ancient Etruscans	[20·86 (18) 20·05 (15)]	Sergi	Neolithic French	99·22 (240)	Rodriguez
Ancient Persians from Anau	20·85 (2)	Mollison	Ancient Slavs	99·03 (43)	,,
Indonesians	20·78 (14)	Rodriguez	Merovingians	98·98 (40)	,,
Basques	20·75 (35)	,,	17th century Londoners	98·86 (335) 99·10 (216)	Pearson and Bell
Phoenicians and Carthaginians	20·74 (16)	,,	Veddahs	98·83 (2)	Rodriguez
Modern Portuguese	[20·72 (264) 20·03 (250)]	de Campos	Japanese	98·82 (92)	,,
Bajuvars, Swabians and Alemanns from Row Graves	20·70 (28) 20·50 (12)	Lehmann-Nitsche	Ancient Persians from Anau	98·75 (2)	Mollison
French Neolithics	20·64 (240)	Rodriguez	Basques	98·73 (35)	Rodriguez
Modern Swiss	20·63 (22)	Schwerz	Franks and Burgundians	98·71 (30)	,,
Neolithic Swiss Dwarfs	20·59 (4)	,,	Laplanders	98·64 (10)	,,
Indo-Chinese	20·59 (16)	Rodriguez	Gauls and Romano-Gauls	98·51 (78)	,,
Neolithic Men from Montigny-Esbly	[20·45 (10) 19·91 (4)]	Manouvrier and Antony	Mediaeval French	98·44 (183)	,,
Malays	20·32 (118)	Rodriguez	Ancient Etruscans	97·97 (20) 98·37 (18)	Sergi
Berbers and Guanches	20·31 (94)	,,	Bajuvars, Swabians and Alemanns from Row Graves	97·00 (28) 97·70 (12)	Lehmann-Nitsche
Polynesians	20·29 (18)	,,	Australians	96·8 (2) 98·7 (2)	Pearson and Bell
Ancient Egyptians	20·11 (22)	,,			
Fossil Negroid from Grimaldi	20·05 (3)	,,		Single entries in the "value" column denote either ♂ + ♀ or sex not stated.	
Maori I	[19·94 (12) 21·46 (3)]	Hepburn			
,, II	19·64 (4)	Mollison			
Canary Islanders	19·81 (287)	Rodriguez			
Negritos	19·81 (42)	,,			
Negroes I	19·69 (97)	,,			
,, II	[19·01 (10) 18·38 (3)]	Hepburn			
Melanesians	19·64 (80)	Rodriguez			
Hindoos I	19·52 (18)	,,			
,, II	[19·40 (6) 17·85 (2)]	Hepburn			
Veddahs	19·32 (2)	Rodriguez			
Australians	[18·59 (12) 16·19 (2)]	Hepburn			
Andamans	[18·50 (8) 19·11 (4)]	,,			

Here the evolutionary drift from Lemuroids to Recent Man appears to have been from a vertical diameter relatively less than the horizontal to one relatively greater. The *Simiinae* make an apparent exception, which is supported by the fossil Gibbon, but Neanderthal Type carries on the decrease in the index, and, as so frequently occurs, appears to overshoot the mark, and there is a return towards the apelike in the Cromagnon and Recent Man femora. It is, perhaps, worth remarking that *Tarsius* has the least and Primogenial Man the greatest robusticity, that *Tarsius* has the greatest index of ellipticity of the head and Primogenial Man (Neanderthal Type) the least! If we suppose *Tarsius* on the direct line of man's ascent, then these femoral features alone compel us to insert troglodyte ancestors.

It would thus seem that the perfection of the head as a Hooke joint is less in modern Europeans than in the apes and in Primogenial Man. Except in certain "fringe" races—Maori, Eskimo and Aino—the vertical diameter always appears to be greater than the horizontal. But the ellipticity is less for modern primitive than it is for modern civilised races, Polynesians, Malays, Negroes and American Indians having small ellipticity. As we have previously stated, however, far larger records and probably greater standardisation and accuracy of measurement are necessary before ellipticity of femoral head can be given much weight as a racial character.

(v) Capito-collar Axis or Bust Length.

It is difficult to find comparatives for our capito-collar axis, *i.e.* length from centre of head to coaxial point. A good many writers measure from centre of head to the spiral line. The difficulty of this measurement is great. In the first place it has relation only to the anterior face, and a good measurement of the bust should be free of aspect; in the next place the spiral line is an area and for any useful measurement some definition is required of how this area is to be reduced to a line; lastly a length must be from one point to a second point, and not to a line, unless we have again a clear definition of how to fix a point in that line. It will not do to say that point where the axis of the neck meets the spiral for then the axis of the neck needs definition and, further, that axis does not meet the spiral line. We are quite aware that our capito-collar axis appears to exceed the epiphysis and to encroach on the diaphysis. But this is to some extent the result of regarding the bone from the *anterior* face, and not the posterior; and it certainly does appeal to a point—the coaxial point—which can be determined with some degree of exactitude. It must be noted that the apparent neck is at least a centimetre longer on the posterior than the anterior face and that on this account the capito-collar axis is a better estimate of the length of neck and head than those who consider the femur solely from its anterior face are likely to give it credit for being. Parsons[1], and again Tamagnini and De Campos[2], need to have 11 to 12 mm. added to their length of neck to render it

[1] Bibl. 111, p. 241.

[2] These Portuguese writers term the length of head and neck "Comprimento do colo," which seems like Parsons' "Length of the Neck" to exclude any name for the true length of the neck itself: see Bibl. 118, p. 9, 10°.

TABLE XXXIV. *Racial Values of Capito-collar Axis and Length of Neck.*

	Race	No.	Capito-collar Axis		Length of Neck*	
Lemuroidea	*Tarsiidae*	2	4·85	Mean 10·33	3·05	Mean 6·38
	Galaginae	6	5·5		3·5	
	Lorisinae	6	8·5		4·9	
	Chiromyrdae	2	12·25		7·1	
	Lemurinae	18	15·3		9·4	
	Indrisinae	8	15·6		10·3	
Cebidae	*Hapalinae*	16	7·5	Mean 17·07	4·6	Mean 11·54
	Nyctipithecinae	8	9·4		5·9	
	Pithecia	2	14·3		9·65	
	Cebus	6	15·1		9·9	
	Brachyurus	2	17·3		11·5	
	Lagothrix	2	17·8		11·65	
	Mycetes	2	21·65		14·9	
	Ateles	4	33·5		24·2	
Simiadae	*Cercopithecus*	8	17·1	Mean 24·55	10·75	Mean 16·12
	Macacus	14	23·5		15·3	
	Semnopithecus	10	23·8		15·3	
	Cercocebus	4	26·2		17·75	
	Cynocephalus	8	32·15		21·5	
	Dryopithecus rhenanus	1	43·4		31·4	
Simiinae	Gorilla	7	77·4	Mean 62·87	54·2	Mean 44·10
	Chimpanzee	2	62·4		44·3	
	Orang-utan	5	48·8		33·8	
	Gibbon	2	26·05		18·5	
	Pithecanthropus erectus	1	74·0		51·5	
Primogenial Man	La Chapelle-aux-Saints	1	82·5	Mean for 6 Neanderthal Type 75·0	56·7	Mean for 6 Neanderthal Type 46·4
	Spy	1	76·2		48·3	
	Galley Hill	1	72·2		47·6	
	Homo aurignacensis (*Hauseri*)	1	69·0		48·5	
	Homo mousteriensis (*Hauseri*)	1	67·0		43·2	
	Neanderthal	1	64·5		37·5	
	Cromagnon	13	84·7		57·6	
	RECENT MAN:		♂	♀	♂	♀
	Modern Germans	(18)	79·8	80·0(!)	55·5	55·7(!)
	Gauls and Romano-Gauls	(78)	78·4	70·7	53·8	48·5
	Mediterranean Race	32	78·3	71·6	54·1	49·5
	Modern French	69	77·9	75·1	54·3	52·3

Race	No.	Capito-collar Axis		Length of Neck*	
		♂	♀	♂	♀
RECENT MAN (*continued*):					
Rothwell English	178, 105	77·7	67·5	53·2	46·2
17th century Londoners	456, 349	77·12	67·89	53·7	47·2
Franks and Burgundians	30	77·1	71·0	52·7	48·5
Mediaeval French	183	77·1	71·0	53·3	49·1
Patagonians	101	77·0	69·1	52·4	47·0
Portuguese	134, 126	76·6	67·3	53·3	47·1
Ancient Slavs	43	75·4	70·0	51·7	48·0
Neolithic Europeans	240	74·4	68·0	51·4	48·0
Veddahs	2	74·3	—	52·8	—
Laplanders	6	74·3	—	51·9	—
Basques	35	74·2	—	51·9	—
Merovingians	40	74·1	68·3	50·9	46·9
Negritos	42	74·1	56·6	50·3	38·4(?)
Berbers and Guanches	94	73·8	69·3	51·0	47·9
Ainos	8	73·8	66·3	51·2	46·0
Ancient Equatorial Indians	126	73·6	67·1	52·1	47·5
Canary Islanders	287	73·4	67·0	51·2	46·8
Fuegians	12	73·4	68·3	50·5	47·0
Eskimo	13	73·4	70·8	50·5	48·7
Negroes (*? locus*)	48	73·1	67·5	50·9	46·9
Bronze Age Europeans	46	72·6	64·0	50·0	44·1
Turks	18	72·6	—	49·1	—
New Guinea Negroes	16	72·4	—	49·7	—
Ancient Bolivians	51	72·2	65·6	50·4	45·9
Prehistoric Naqada Egyptians	43, 61	71·60	65·13	—	—
Ancient Egyptians	22	71·6	69·1	49·6	47·9
Japanese	92	71·5	65·5	48·7	44·7
Polynesians	18	71·5	66·7	48·8	45·5
Mozambique Negroes	13	71·0	66·2	48·9	45·6
Ancient Venezuelians	43	70·8	65·9	48·8	45·4
Phoenicians and Carthaginians	16	70·4	64·6	47·6	43·7
Peruvian Indians	75	70·1	66·0	48·1	45·2
Ancient Mexicans	22	69·7	64·7	47·5	44·1
Californian Indians	122	69·1	64·0	47·5	44·0
Indo-Chinese	16	69·5	67·4	47·7	46·3
Congolese	20	69·3	62·5	47·9	43·2
Melanesians	80	68·5	63·5	46·6	43·2
Maori	5	68·2		48·6	
Chinese	6	67·6	65·8	45·0	43·7
Indonesians	14	67·5	60·7	45·3	40·8
Hindoos	18	66·4	65·3	46·0	45·3
Malays	118	65·6	59·8	44·1	40·2
Neolithic Swiss Dwarfs	4	59·8		40·8	

* This measurement is the conventional one = Capito-collar Axis – half Vertical Diameter of Head.

comparable with our capito-collar axis. Warren obtained by appreciation of coaxial point first on anterior and then on posterior face and averaging his results values for neck + head in the prehistoric Egyptian or Naqada femora[1]. A longer list of racial values may be obtained by reconstruction from Rodriguez's published results, and these we have used to the full as they appear most in accordance with our own measurements, although Rodriguez does not state very fully how the capito-collar length which must have been used to obtain his index was determined. We have added our own determinations of this length for the apes and Primogenial Man, thus providing the table on p. 361.

Summarising this table as before we find :

	Length of Bust (Capito-collar Axis)	*Length of Neck* (Capito-collar Axis less ½ Vertical Diameter of Head)
Lemuroids	10·33	6·38
Cebidae	17·07	11·54
Simiadae	24·55	16·12
Recent Gibbon	26·05	18·5
Dryopithecus rhenanus	43·4	31·4
Greater Anthropoids	62·87	44·10
Neanderthal Type	75·0	46·4
Cromagnon Type	84·7	57·6
Recent Man	♂ (46) 72·87, ♀ (41) 67·14	♂ 50·23, ♀ 46·07
Recent Man (87 and 85 racial groups)	♂ + ♀ 70·17	♂ + ♀ 48·27
17th century Londoners	♂ 77·12, ♀ 67·89	♂ 53·7, ♀ 47·2
„ „ „	♂ + ♀ 73·12	♂ + ♀ 50·88

We see that this summary marks out exactly as each absolute length has done the steady increase in size up to the Greater Anthropoids. The *Cebidae* as usual move in development from a Lemuroid ancestry, in the same direction as the *Simiadae* but less markedly; they belong to an earlier stage than the *Simiadae*. Then comes the great advance in size with Neanderthal Man, still more emphasised in Cromagnon from which point Recent Man has reverted to a more Neanderthal, if not a more ape-like size. Of Recent Man it is noteworthy that the longest busts and necks are to be found in the modern Europeans and their historic ancestors[2]. Absolutely short busts and necks in the Chinese, Melanesians and Malays. The Negroes followed by Eskimo and Fuegians appear to be for these characters nearest to type. As usual, however, beyond illustrating the broad line of development but little satisfaction can be obtained from absolute measurements. In this case they only evidence the necessity for a troglodyte rather than a hylobatic ancestry for Man. We turn then to the relative size of the bust.

[1] Bibl. 77, p. 137.

[2] This result would be shaken if we could place any trust in the *four* Australian femora in our own possession which give :

Capito-collar Length ♂ 81·1 (2), ♀ 59·05 (2),
Length of Neck ... ♂ 56·6 (2), ♀ 37·7 (2).

(vi) Primary and Secondary Bust Ratios.

The Primary Bust Ratio is 100 × capito-collar length divided by the maximum length and the Secondary Bust Ratio replaces the maximum by the oblique length. These ratios are important, but it is almost impossible to obtain good comparative data. Rodriguez's measurements are really the only results which can with profit be placed in the same table as our own. Evangeli-Tramond[1] measures the "Longeur du col" of French femora in 81 cases. He neither describes his method of measurement, nor states his units of measurement. Supposing that 8·4 in the column headed "Longeur du col" means 8·4 cms., we find from his tables:

Length of Neck.

♂ (40) 89·18 mm. ♀ (41) 74·54 mm.

He further gives (p. 19) for mean length of femur:

♂ 43·65 ♀ 39·7.

We presume that these refer to the oblique length in cms. In this case the order of his Secondary Bust Ratio would be

♂ 20·4 ♀ 18·8.

Such excessive values for the length of neck and the Bust Ratio are not to be found in any race of mankind. The Bust Ratio for the males approaches that of the gorilla, and for the females that of the orang-utan. Clearly he has not measured to the coaxial point and *à fortiori* not to the spiral line. Rodriguez gives for modern French ♂+♀ 17·27, which is in keeping with our ♂+♀ 17·11 for 17th century Londoners. Again the difference between the sexes for both absolute and relative neck measurements as given by Evangeli-Tramond is very suspicious. The following table shows the sexual differences in the Bust Ratios obtained from the data of various authorities.

It will be seen that Evangeli-Tramond and Parsons stand alone in their extreme emphasis of sexual difference in the Bust Ratio. The more reliable measurements do not show more than half a point, but Evangeli-Tramond has 1·7 and Parsons even 3·0 sexual difference. We believe that this difference is not real, but arises from over-emphasis of the bust size, in particular of the size of the head in sexing[2].

It must not, however, be supposed that the following table gives true *racial* differences. We obtain the coaxial point by diagraphic methods, so we believe did Rodriguez and probably Antony and Rivet. Warren obtains it by appreciation, averaging for both anterior and posterior faces. Koganei measures to the trochanteric crest, Evangeli-Tramond has done something of an individual nature and gives no account of it. Tamagnini and de Campos appear to have used the spiral line, but

[1] Bibl. 65.

[2] The Portuguese data confirm our London data in making the value of the Bust Ratio greater on the left than on the right side. Parsons gets no uniformity of this kind, which makes us still further distrust his results for the femoral neck.

neither they nor Parsons state clearly what they have done. Accordingly for comparative purposes we have rejected all but Rodriguez's data. We have combined as he does the sexes, using only the Secondary Bust Ratio. Probably Mollison for a few Maori femora and Schwerz for the neolithic Swiss Dwarfs may be safely included.

TABLE XXXV. *Primary and Secondary Bust Ratios.*

Group		Authority	Primary Bust Ratio		Secondary Bust Ratio	
			♂	♀	♂	♀
Lemuroids	*Tarsiidae*	Pearson & Bell	7·55 (2)	♂ + ♀	7·55 (2)	♂ + ♀
	Chiromyrdae ...	,,	9·8 (2)	,,	9·8 (2)	,,
	Galaginae	,,	10·05 (6)	,,	10·1 (6)	,,
	Indrisinae	,,	10·6 (8)	,,	10·6 (8)	,,
	Lorisinae	,,	11·0 (6)	,,	11·0 (6)	,,
	Lemurinae	,,	11·8 (18) Mean 10·13	,,	11·8 (18) Mean 10·16	,,
Cebidae	*Nyctipithecinae* ...	Pearson & Bell	10·7 (8)	♂ + ♀	10·7 (8)	♂ + ♀
	Pithecia	,,	11·05 (2)	,,	11·05 (2)	,,
	Brachyurus	,,	11·15 (2)	,,	11·2 (2)	,,
	Hapalinae	,,	11·2 (16)	,,	11·2 (16)	,,
	Cebus	,,	12·7 (6)	,,	12·7 (6)	,,
	Mycetes	,,	14·25 (2) Mean 12·74	,,	14·25 (2) Mean 12·76	,,
	Ateles	,,	15·0 (4)	,,	15·0 (4)	,,
	Lagothrix	,,	15·9 (2)	,,	15·95 (2)	,,
Simiadae	*Semnopithecus* ...	Pearson & Bell	11·7 (10)	♂ + ♀	11·7 (10)	♂ + ♀
	Cercocebus	,,	11·9 (4)	,,	12·0 (4)	,,
	Cercopithecus ...	,,	12·1 (8)	,,	12·1 (8)	,,
	Cynocephalus ...	,,	14·0 (8)	,,	14·0 (8)	,,
	Macacus	,,	14·3 (14) Mean 12·80	,,	14·3 (14) Mean 12·84	,,
Simiinae	Gibbon	Pearson & Bell	13·4 (2)	♂ + ♀	13·4 (2)	♂ + ♀
	Dryopithecus rhenanus	,,	15·1 (1) Mean 21·08	♂ or ♀	15·2 (1) Mean 21·20	♂ or ♀
	Chimpanzee	,,	19·85 (2)	—	20·05 (2)	—
	Orang-utan	,,	20·6 (5)	♂ + ♀	20·7 (5)	♂ + ♀
	Gorilla	,,	22·8 (4) Mean 14·25	22·1 (3)	22·85 (4) Mean 14·3	22·3 (3)
17th century Londoners		Pearson & Bell	17·24 (427)	16·66 (326)	17·35 (405)	16·78 (305)
Paltacalo Indians ...		Antony & Rivet	17·93 (60)	17·37 (47)	18·13 (60)	17·61 (47)
Australians		Pearson & Bell	17·95 (2)	14·75 (2)	18·25 (2)	14·9 (2)
Naqada Egyptians ...		Warren	15·90 (45)	15·40 (87)	16·02 (45)	15·55 (87)
Portuguese		Tamagnini & de Campos	14·42 (134)	13·90 (126)	14·53 (134)	14·10 (126)
Japanese		Koganei	16·81 (20)	16·32 (20)	—	—
Aino		,,	16·65 (42)	16·22 (24)	—	—
French (Modern) ...		Evangeli-Tramond	—	—	20·43 (40)	18·78 (41)
Rothwell English ...		Parsons	16·57 (160)	13·50 (102)	16·69 (160)	13·58 (102)

A comparison of our values for Primary and Secondary Indices suffices to demonstrate that it is quite idle to take *both*. It only remains for femoralogists to settle which they will take, so that future investigators may be saved from the labour of taking both. The difference in the Lemuroids and monkeys is never greater than ·05, in the Anthropoids and Man it may amount to ·1 to ·2. Such differences

TABLE XXXV *bis.* *Table of the Secondary Bust Ratio* $= 100 \frac{\text{Capito-collar Length}}{\text{Oblique Length}}$.

	Race	No.	Value (♂ + ♀)		Race	No	Value (♂ + ♀)
Simiinae	Gorilla	46	22·9	20·83	RECENT MAN (*continued*):		
	Orang-utan	6	20·7		Gauls and Romano-Gauls	78	17·03
	Chimpanzee	25	18·9		Aino	8	17·01
	Gibbon	24	13·6		Maori	5	17·01
					Turks	18	16·97
	Pithecanthropus erectus	1	16·4		Bronze Age Europeans	46	16·82
Primogenial Man	La Chapelle-aux-Saints	1	19·2		Veddahs	2	16·79
	Man of Spy	1	17·9*		Merovingians	40	16·76
	Homo mousteriensis (*Hauseri*)	1	17·9		Franks and Burgundians	30	16·75
	Galley Hill	1	17·5		Neolithic Europeans	240	16·74
	Homo aurignacensis (*Hauseri*)	1	16·3		Patagonians	101	16·66
	Neanderthal	1	14·8		Berbers and Guanches	94	16·48
					Indo-Chinese	16	16·48
	Cromagnon	13	16·98		Canary Islanders	287	16·46
					Ancient Egyptians	22	16·41
Recent Man	Laplanders	6	18·56		Chinese	6	16·40
	Basques	35	17·42		Negroes (*? locus*)	48	16·28
	Japanese	92	17·41		Phoenicians and Carthaginians	16	16·08
	Modern Germans	18	17·36		Neolithic Swiss Dwarfs	4	16·03
	Mediterranean Race	32	17·33		New Guinea Negroes	16	16·00
	Eskimo	13	17·28		Hindoos	18	15·97
	Modern French	69	17·27		Polynesians	18	15·95
	Mediaeval French	183	17·17		Indonesians	14	15·84
	Ancient Indians of Equatorial and South America	452	17·17		Mozambique Negroes	13	15·79
					Malays	118	15·54
	17th century Londoners	753	17·11		Congolese	20	15·49
	Ancient Slavs	43	17·06		Negritos	42	15·43
					Melanesians	80	15·40

* Rodriguez gives a value 19·9 for Man of Spy. This does not seem to us in accordance with the photographs or cast.

occurring in practice make no sensible changes in the racial order. Summarising our results as before we find[1]:

Lemuroids	10·16
Cebidae	12·76
Simiadae	12·84
Gibbons, fossil and recent	14·13
Greater Anthropoids	20·83
Neanderthal Type (6)	17·7
Galley Hill	17·5
Cromagnon Type (13)	16·98
Recent Man (38 racial groups)	16·62
17th century Londoners	17·11.

We see from these results that the relative size of the bust increased from the Lemuroids right up to the Greater Anthropoids. The practical equality of the indices of *Cebidae*

[1] We may note that for the relative bust length the type is given by the *Galaginae* for the Lemuroids, by *Cebus* for the *Cebidae*, by *Cercopithecus* for the *Simiadae* and by the Orang for the *Simiinae*.

and *Simiadae* suggests that the proportionate value of the bust was fixed before the separation of Old and New World monkeys. Man lies between Gibbon and Chimpanzee, being considerably nearer to the latter—another argument in favour of the femur of the protsimio-human being troglodytic. From the Neanderthal Type, however, there is a considerable fall through Galley Hill and Cromagnon to the mean of Recent Man (16·62). *Pithecanthropus erectus* is as usual purely human, in fact in the same group as the Chinese. The Laplanders possess the relatively longest bust; the shortest busts are those of the negroid races. We may divide all femora into five classes according to the value of their bust ratio, namely:

Hyperdolicho-auchenic		above 17·60
Dolicho-auchenic	...	17·60 to 16·90
Meso-auchenic	...	16·90 to 16·20
Brachy-auchenic	...	16·20 to 15·50
Hypobrachy-auchenic		below 15·50.

The hyperdolicho-auchenic class contains the Greater Anthropoids, Neanderthal Man and of Recent Man only the Laplanders. The dolicho-auchenic class contains a large portion of modern Europeans but also the Japanese, Aino, and Maori and American Indians. The meso-auchenic class the early historic and prehistoric Europeans, the Patagonians and Chinese. The brachy-auchenic class the bulk of the Negroes, the Malays and Polynesians, while the hypobrachy-auchenic class contains the remainder of the Negroes and the Melanesians as well as the Gibbons and Lesser Apes. It will be seen that the divisions by no means correspond to well-marked racial distinctions, and it seems possible that this character may have been largely adapted to local conditions.

(vii) The Collar (or Cervical Angle).

We believe that with the existing absence of standardisation in the determination of the collar angle it is almost idle to exhibit the results obtained by different authorities in a single table. There appear to us grave objections to the determination of the coaxial point by the use only of the anterior face. Warren endeavoured to surmount this difficulty by considering the coaxial point on both faces. We believe that the collar angle found by appreciation of the capito-collar axis on either face, whether by use of threads or not, is subject to very great personal equation. The method we have used for the 17th century London femora, for the ape femora and the casts of the primogenial femora is a straightforward if laborious one, and admits of little personal equation. It is essentially the same as a dioptical one—the plane of projection being the standard vertical plane. Hence our method should agree with dioptical processes provided the axes of shaft and neck are selected in the same manner. It will be remembered that we do this by (*a*) the selection of two points, *i.e.* (i) the centre of the head (which must be determined by a tape measure and not taken "just above the fovea"), and (ii) the mid-trochlear point, and (*b*) the selection of two diameters, (i) the minimum vertical diameter of the neck, and (ii) the transverse platymeric diameter. The use of this projection method may raise 10° the angle

obtained by the double aspect method. That is to say the change covers the entire racial variation in man or in the apes! After some consideration of the matter we have found that the projection method is very roughly about 4° in excess of the anterior face appreciation. We say very roughly because so much depends in the latter method on personal equation. Even if such a correction be reasonable we are in many cases quite unable to discover what method an osteologist has actually used for his determinations. Many seem to have approached the point without any apparent sense of the gruesome difficulties by which it is surrounded.

In order that the reader may not think we are exaggerating the present state of chaos in this important matter, let us look at a few results. Prochownick[1] (who, by the by, only appears to read his angles to the nearest 5°!) gives the collar angle for Australians as 119·0°. This places them about the bottom of the racial scale, and appears a not unreasonable position. Lustig[2]—almost as an aside, and without statement as to method used or as to the number dealt with—says that the collar angle of Australians is 130°, thus removing the Australians to about the top of the human scale! Martin in his table of this angle[3] reproduces Lustig and overlooks Prochownick and quite probably 130° will pass for years as the collar angle of the Australian femur! Now both our authorities may be in error, or both may be right if they have used one the double appreciation and the other a dioptical projection[4]. But we ask what progress can be made in interracial anthropometry until we have greater standardisation, greater appreciation of the real difficulties of our task, and a more detailed statement of methods? Such obscurities are not only attached to cases in which the data are sparse. Many writers have dealt with the collar angle of the modern French femur. Taking the French male we find the following values:

Evangeli-Tramond	124°
Bertaux	125°
Rodriguez	126°
Charpy	127°
Rodet	131°

Similar results can be provided for the German tribes. Mikulicz gives Modern Viennese 127°; this agrees with Rodriguez's Modern "Germans" 127° and Bumüller's Modern Bavarians 127°, but differs hopelessly from Langer's Modern "Germans" 130° or Martin's Modern German Swiss 133°. We believe that the difference here exhibited is simply the result of an anterior face appreciation, and the use of what

[1] Bibl. 43.

[2] *Korrespondenz-Blatt für Anthropologie*, Jahrgang XLIV. S. 115, 1913.

[3] Bibl. 111 *bis*, S. 1028.

[4] There is another solution suggested by the four Australian femora in the Biometric Laboratory which give ♂ 120°·15 (2), ♀ 136°·25 (2), *i.e.* that there is among the Australian aborigines a marked sex difference, and that Prochownick had chiefly male and Lustig female bones. Lustig gives the trochanteric lengths, however, of 11 Australian femora (*l.c.* S. 114) of which the mean value is 418·5. If these femora are what he obtained his 130° from, such a mean would be rather male than female. On the other hand the mean proximal breadth of his material, 80·6, is very female unless his character be measured very differently from ours. We find ♂ 104·8 (2) and ♀ 87·25 (2). Against such a difference of measurement must be put that his mean for Neanderthal Type is 102·4 (5) while ours is 102·0 (7)—well in accord.

probably amounts to the dioptical method. Mollison's Ancient Persians (135°) and Maori (130°) are probably high for the same reason. On the other hand Rodriguez's long series of racial results are inter-comparable, and it would appear that Veddahs, Melanesians and Negritos have really a high collar angle; Fuegians, prehistoric American Indians and Guanches a low one like the Australians. Our own results indicate that Primogenial Man had a low collar angle and if Prochownick be correct the Australians resemble him in this respect while differing from him in so many other femoral characters. Modern Man has a mediocre collar angle, primitive races as a rule being one or other extreme. This scission of the low races by the high, which occurs in various femoral characters, cannot be disregarded, but it would be unwise at present to pursue its suggestiveness until at least standardised data are forthcoming. The anthropoids provide also a wide range—as wide as or indeed wider than in man—the gorilla at one end and the orang-utan at the other. Primogenial Man has a gorilloid collar angle, the Veddahs, Melanesians and Negritos follow the orang. In this respect there is hardly the marked distinction between Neanderthal Man and *Homo aurignacensis* that Klaatsch's analogy[1] (Neanderthal to gorilla and orang to *Homo aurignacensis*) demands. *Pithecanthropus erectus* and Galley Hill have modern values, while the Cromagnon Type—to judge by Rodriguez's value (126°·0) shows in this respect no differentiation from the modern European.

As we have stated, all comparisons are probably premature until we have definite standardisation, but even with the material as it stands it may be doubted whether a narrowly limited range of collar angle is closely associated with a particular species following a definite mode of progression or habit of life. Thus we have:

Primogenial Man, Neanderthal Type	115°·0
Gorilla	119°·8
Caroline Islanders	122°·3
Tigress[2]	123°·0
Fuegians	123°·5
Gibbon	123°·9
Deer[2]	125°·0
Modern English[2]	126°·0
Ass[2]	127°·0
Negroes	127°·1
Chimpanzee	127°·1
Japanese	128°·0
Puma[2]	128°·0
Malays	129°·0
Negritos	132°·6
Orang-utan	133°·0

a table which must give us "furiously to think," if we maintain both the accuracy of the measurements, and the evolutionary importance of the collar angle!

[1] Bibl. 102 *ter*. [2] Walmsley, Bibl. 113.

If we confine our attention purely to results of our own determination we have:

	Lemuroids (42)	...	114°·04
	Cebidae (42)	...	121°·17
	Simiadae (44)	...	116°·31
	Dryopithecus rhenanus (1)	...	125°·5
	Gibbon (2)	...	114°·5
Greater Anthropoids:	Gorilla (7) 114°·3 Chimpanzee (2) 133°·5 Orang-utan (5) 138°·7	...	128°·9
	Neanderthal Type (6)	...	115°·0
	Galley Hill (1)	...	126°·0
	Cromagnon Type (5)	...	126°·0
	Grimaldi Type (2)	...	128°·0
	17th century Londoners (805)		130°·2

This summary shows that the collar angle increased from the Lemuroids to the Greater Anthropoids, the *Cebidae*, however, advancing further than the *Simiadae*. The Recent Gibbon appears to have dropped on the fossil *Dryopithecus*, although 24 Gibbon collar angles collected from various sources and so determined probably by a variety of methods give nearly 124°, and correspond more closely with *Dryopithecus*. There comes the usual sudden drop with Neanderthal Man, followed by a rise through the later forms of Primogenial Man to Recent Man, whose collar angle has a value slightly on the gorilla side of the Chimpanzee, *i.e.* is troglodytic and not hylobatic. For the Lemuroids and *Cebidae*, we have again the *Galaginae* and *Cebus* respectively as types for this character. For the *Simiadae* we have, what is very exceptional, *Cynocephalus*, and for the *Simiinae* the very usual Chimpanzee.

Amid all the difficulties of the general table certain points appear to emerge clearly, namely:

(i) There are no significant differences in collar angle between modern European races.

(ii) There are no significant differences between modern Europeans and early historical Europeans.

(iii) There are no significant differences between early historical Europeans and neolithic European man[1].

But on the other hand:

(iv) There are marked differences between European palaeolithic and neolithic man.

(v) There are marked differences between the Australian, Pacific and American races and European races.

(vi) The African negro (127°·1) shows no significant difference from the European white. (This is confirmed by Manouvrier's value (126°·8) for the collar angle of the negro.)

[1] Kuhff's measurements on small series are out of serial order, we believe, owing to personal equation. They are 4° to 5° below those of Rodriguez for similar groups.

Table XXXVI. *Collar Angle* (*i.e.* Angle of Neck and Shaft).

	Race	Value ♂	Value ♂ + ♀	Value ♀	Source
Lemuroids	*Tarsiidae*		109°·0 (2)	Mean 114°·04	Pearson and Bell
	Lemurinae		109°·25 (18)		,,
	Indrisinae		112°·2 (8)		,,
	Galaginae		114°·1 (6)		,,
	Chiromyrdae		117°·0 (2)		,,
	Lorisinae		122°·7 (6)		,,
Cebidae	*Mycetes*		115°·0 (2)	Mean 121°·17	Pearson and Bell
	Lagothrix		118°·0 (2)		,,
	Hapalinae		118°·5 (16)		,,
	Nyctipithecinae		120°·0 (8)		,,
	Pithecia		120°·5 (2)		,,
	Cebus		121°·0 (6)		,,
	Ateles		125°·9 (4)		,,
	Brachyurus		130°·5 (2)		,,
Simiadae	*Cercopithecus*		112°·3 (8)	Mean 116°·31	Pearson and Bell
	Cynocephalus		116°·4 (8)		,,
	Semnopithecus		116°·95 (10)		,,
	Cercocebus		117°·5 (4)		,,
	Macacus		118°·4 (14)		,,
Simiinae	Orang-utan		137°·2 (10)		Various
	Chimpanzee		127°·1 (35)		,,
	Gibbon		123°·9 (24)		,,
	Gorilla		119°·8 (62)		,,
	Dryopithecus rhenanus		125°·5 (1)		Cast

Race	Value ♂	Value ♂ + ♀	Value ♀	Source
Pithecanthropus erectus ...		124°·0 (1)		Dubois
Galley Hill		126°·0 (1)	Neanderthal (6) 115°·0	Cast
Neanderthal		123°·5 (1)		,,
Homo aurignacensis (*Hauseri*)		[120°] (1)		Photographs
Homo mousteriensis (*Hauseri*)		112°·5 (1)		Cast
Spy		112°·0 (1)		,,
La Chapelle-aux-Saints ...		112°·0 (1)		Photographs
Carlovingians		119°·0 (4)		Kuhff
Australians	119°·0 (5)	120°·0 (4)		Prochownick
17th century Londoners ("both faces") ...		120°·3 (456)	120°·5 (349)	Present Memoir
Prehistoric Paltacalo Indians		121°·1 (63)	121°·4 (49)	Antony and Rivet
Gallo-Romans		122°·0 (6)		Kuhff
Dolmens of the Lozère ...		122°·0 (5)		,,
Caroline Islanders		122°·1 (5)	122°·5 (4)	Prochownick
Fuegians		123°·0 (5)		Martin
Fuegians		123°·5 (10)		Hultkrantz
Viti Islanders		123°·6 (24)	117°·9 (7)	Prochownick
Modern French (Paris?) ...		124°·05 (25)	124°·07 (14)	Bertaux
Prehistoric Indians of Equatorial and South America		124°·2 (452)		Rodriguez
Modern French (Paris?) ...		124°·2 (61)	128°·4 (60)	Evangeli-Tramond
Neolithic French from Montigny ...		124°·2 (20)	128°·8 (4)	Manouvrier and Antony
Fuegians		124°·3 (12)		Rodriguez
Neolithic Swiss Dwarfs ...		124°·0 (4)		Schwerz
Chinese		124°·2 (6)		Rodriguez
Naqada Egyptians ("both faces") ...		124°·3 (45)	126°·8 (88)	Warren

Race	Value ♂	Value ♂ + ♀	Value ♀	Source
Berbers and Guanches ...		124°·6 (94)		Rodriguez
Ainos		124°·8 (8)		,,
Turks		124°·8 (18)		,,
Phoenicians and Carthaginians ...		124°·8 (16)		,,
Neolithic French (Caverne de l'homme mort)		125°·0 (8)		Kuhff
Laplanders		125°·0 (6)		Rodriguez
Modern English	125°·0 (15)	127°·0 (15)		Walmsley
Bajuvars, Swabians and Alemanns from Row Graves ...	125°·3 (45)	127°·2 (17)		Lehmann-Nitsche
Modern French		125°·8 (69)		Rodriguez
Modern French	125°·8 (169)	125°·8 (69)		Various
Canary Islanders		125°·9 (287)		Rodriguez
Merovingians		125°·9 (40)		,,
Neolithic Man (France) ...	126°·4 (53)	128°·2 (8)		Various
Rothwell English	126°·2 (183)	125°·4 (187)		Parsons
Swiss Alemanns	126°·3 (c. 163)	126°·5 (c. 163)		Schwerz
Neolithic Man (Brazil) ...	126°·4 (10)	126°·5 (7)		Manouvrier and Antony
Ancient Slavs		126°·5 (43)		Rodriguez
Neolithic Swiss (Chamblands)	126°·7 (17)	129°·1 (11)		Schenk
Basques		126°·7 (35)		Rodriguez
Modern Portuguese ...	126°·8 (134)	125°·1 (126)		Tamagnini and de Campos
Modern Viennese		126°·9 (100) (? ♂)		Mikulicz
17th century Londoners ("anterior face") ...	126°·9 (456)	125°·8 (349)		Pearson and Bell
Modern French	127°·0 (c. 25)	128°·0 (c. 25)		Charpy
Negroes (various localities)		127°·1 (97)		Rodriguez
Modern Bavarians	127°·2 (179)	126°·4 (29)		Bumüller
Modern "Germans" ...		127°·2 (18)		Rodriguez
Gauls and Romano-Gauls ...		127°·3 (78)		Rodriguez
"Ancient Egyptians" ...		127°·3 (22)		,,
Mediaeval French		127°·6 (183)		,,
Indo-Chinese		127°·7 (16)		,,
Polynesians		127°·6 (18)		,,
Franks and Burgundians ...		128°·0 (30)		,,
Men of Bronze Age (France)		128°·0 (46)		,,
Neolithic Man (France) ...		128°·2 (240)		,,
Japanese		128°·2 (92)		,,
Modern Bolognese	128°·5 (20)	126°·3 (23)		Zanolli
Neolithic Man (Châlons-sur-Marne) ...	128°·5 (23)	128°·2 (8)		Manouvrier
Eskimo		128°·7 (13)		Rodriguez
Neolithic Man, France (Baye) ...		129°·0 (19)		Kuhff
Malays		129°·0 (18)		Rodriguez
Patagonians		129°·0 (101)		,,
Indonesians		129°·5 (4)		,,
Modern Germans		130°·0 (??)		Langer
Veddahs		130°·0 (2)		Rodriguez
Australians		130°·0 (– ?)		Lustig
Hindoos		130°·2 (8)		Rodriguez
Maori		130°·4 (5)		Mollison
Naqada Prehistoric Egyptians ...	130°·9 (45)	133°·4 (88)		Warren, corrected to "anterior face" only
17th century Londoners (projection method) ...	130°·9 (456)	129°·8 (349)		Present Memoir
Modern French	131°·0 (c. 12)	129°·0 (c. 12)		Rodet
Melanesians		132°·0 (80)		Rodriguez
Negritos		132°·6 (42)		,,
Modern Swiss		133°·0 (– ?)		Martin
Ancient Persians from Anau		135°·3 (3)		Mollison

The reader is especially cautioned that at least three different methods (all illustrated on the 17th century Londoners) have been used by different investigators, and that this largely accounts for eccentricities in the serial order. The appearance of modern Europeans in the lower end of the table is probably due entirely to the use of the more correct projection method.

(vii) The Negro of Africa differs, however, from the Melanesians and Negritos, who have the most extreme collar angle hitherto recorded[1].

What is chiefly needed at the present time is a remeasurement of several sets of Rodriguez's series by the projection method in order to determine what correction is needful for comparative purposes.

We now turn to other features of the collar angle. Hirsch[2] without a really adequate amount of data has asserted that there is a relation between the size of the collar angle and (i) the shape of the cross-section of the neck, and (ii) the shape of the cross-section of the shaft in the subtrochanteric region. We have tested this by correlating the collar angle in our 17th century Londoners with (i) the primary index of the neck, and (ii) the platymeric index. We found the following values:

Correlation Coefficient	♂		♀	
	R.	L.	R.	L.
Collar Angle and Index of Neck ...	(221) $+ \cdot 016 \pm \cdot 045$	(227) $+ \cdot 098 \pm \cdot 044$	(157) $+ \cdot 248 \pm \cdot 051$	(180) $+ \cdot 319 \pm \cdot 045$
Collar Angle and Platymeric Index	(230) $+ \cdot 422 \pm \cdot 037$	(231) $+ \cdot 310 \pm \cdot 040$	(164) $+ \cdot 259 \pm \cdot 049$	(183) $+ \cdot 456 \pm \cdot 039$

The numbers in brackets are those of the population dealt with.

It will be seen that the collar angle is sensibly related to the shape of the shaft at the platymeric section—the rounder the shaft or the less the platymery the greater the collar angle. This probably only means that a low collar angle in man, involving the neck springing more horizontally from the shaft, increases the subtrochanteric transverse diameter and so reduces the platymeric index, *i.e.* increases the platymery.

In the case of the female there is a small but quite sensible correlation between a high collar angle and a high neck index. The relationship is hardly sensible for males, but as it is in both cases of the same sign as the females, we may assume it to exist in the male, although in reduced intensity. A high neck index means a relatively small diameter for the neck in the vertical plane, and consequently less resistance to bending moment. But with a high collar angle there will be greater thrust and less bending moment for the same body weight. Thus mechanically the relationship might be justified as an economical use of the available material.

The point if a small one seemed worth pursuing further; in particular because a study of the anterior and posterior flattening of the femur in the trochanteric region in a long series of primates had convinced us that the platymeric index taken in the *subtrochanteric* region was a very partial measure of this flattening. Accordingly the correlations between the collar angle and both platymeric index and ellipticity of the neck were determined for 80 species of primates; these included eight races of man covering recent and primogenial types, *Pithecanthropus erectus*, two fossil apes,

[1] The place as already stated of our 17th century Londoners, and of Martin, Mollison and Rodet's results, is probably due to the use of a projection method.

[2] Bibl. 82, S. 678—9.

five species of Anthropoids, 23 species of Old World apes, 20 species of New World apes and 22 Lemuroids. The following results were reached:

Interspecial Constants for Primates.

	Collar Angle	Platymeric Index	Ellipticity of Neck
Mean	117°·59 ...	91·06 ...	73·92
Standard deviation	7°·96 ...	9·929 ...	8·265

Correlation Coefficient of Collar Angle and Platymeric Index $-\cdot1701 \pm \cdot0518$

„ „ „ „ Ellipticity of Neck $+\cdot2403 \pm \cdot0512$

These results are of interest; the correlations are small but sensible. They indicate that throughout the primates there exists a small relationship between the shape and slope of the neck, the greater the angle the neck makes with the *vertical* the greater the ellipticity of the neck, *i.e.* the vertical diameter of the neck increases relatively to the horizontal diameter as the neck becomes more horizontal. On the other hand the interspecial correlation of collar angle and platymeric index does not confirm the intraspecial value as found for one race of man,—but is of negative sign,—a high collar angle being associated with a low platymeric index. In fact the high collar angles occur usually in Man and the Anthropoids, and occasionally in certain South American monkeys (*e.g. Cebus*, *Chrysothrix*, and *Callithrix*), and in certain Lemuroids (*e.g. Potto* and *Loris gracilis*), but in all these cases there is considerable platymery, while where the platymery is low or the platymeric index high, as in the *Semnopithecidae* and *Cercopithecidae*, the collar angle is relatively low. Even with the few Lemuroids (*e.g. Galago crassicaudatus* and *Chirogaleus*) where a high platymeric index may be reached the collar angle is below the primate mean. Thus with the primates as a whole a rounded shaft in the subtrochanteric region is slightly associated with a horizontally tending neck—the reverse of what we find in the case of the human femur.

A point which lies somewhat aside from our present topic, but which the reader may pardon if thrown out merely as a suggestion at this stage of our investigation, is this: The mean of the primate constants, if we suppose evolution to have spread out the members of this group in a fairly balanced manner, may roughly suggest the direction in which we might search for the primitive primate type. The following constants are interesting from this standpoint:

	Collar Angle	Platymeric Index	Ellipticity of Neck
*Homo sapiens** ...	127°·3	77·3	78·8
Mean of Primates ...	117°·6	91·1	73·9
Lagothrix	118° 0	94·3	76·9
Tarsius spectrum ...	109°·0	88·8	58·2

* Mean for a large number of races of Recent Man.

The values for *Lagothrix* are about as close to the primate values as any species we have come across, and in many respects its femur appears to us to be of a primitive type. It seems more reasonable to suggest that the higher primates have been evolved

from some such form as *Lagothrix* on their way from the Lemuroids, rather than to link them up with *Tarsius* directly, which may after all be a side track[1]. Be this as it may the last word on the evolutionary history of the primates will not, we believe, have been spoken—especially from the osteological side—until we know the inter-special means and correlations for a number of characters of various parts of the primate skeleton.

(viii) Indices of the Neck.

The two principal indices of the neck are (*a*) the Primary Index or Ellipticity of the Neck measured by 100 × the Ratio of the Minimum Horizontal Diameter to the Minimum Vertical Diameter of the Neck, and (*b*) the Secondary Index which is measured by 100 × Ratio of the Minimum Horizontal Diameter of the Neck to the Horizontal Diameter of the Head. Unfortunately we have not much data for either of these indices.

Bertaux uses as his Index of the Neck 100 × Vertical Diameter/Horizontal Diameter, *i.e.* the inverse of ours. Evangeli-Tramond also uses this inverse[2]. In the case of what we have called Bertaux's 1st Series, his *Série déterminée*, *i.e.* that in which sex, age and stature were known, we have inverted all his indices and taken their mean value. In this way we determined a correction to pass from the inverse of the mean to the mean of the inverses, and applied this correction to his other series, for which, however, we recalculated the means of his indices as we did not agree with them. It will be seen that thus modified his results for the French now agree closely with ours for the English. Our usual form of summary provides the following series for the Ellipticity of Neck :

Lemuroids	73·25
Cebidae	74·26
Simiadae	76·70
Greater Anthropoids	75·73
Recent Gibbon	80·5
Dryopithecus rhenanus	85·1
Neanderthal Type (6)	84·5 ?
Recent Man (mean 20 racial groups) ...	77·50
17th century Londoners	76·3

Now these results are somewhat noteworthy. The *Cebidae* rise slightly on the Lemuroids, but from the Lemuroids through the *Simiadae* to the Greater Anthropoids

[1] F. Wood-Jones : *Arboreal Man*, London, 1916, and *The Problem of Man's Ancestry*, London, 1918.

[2] We regret not being able to use Evangeli-Tramond's results. We recalculated all the indices from his measurements as we had found inaccuracies and we thus obtained the results

♂ R. (30) 88·07 ♂ L. (7) 79·98 ♀ R. (30) 83·19 ♀ L. (30) 86·37

or ♂ (R. + L.) (37) 86·54 ♀ (R. + L.) (60) 84·72.

These values, presumably for French, are incomparable with anything else in our table. His manner of measurement, not defined, must have been wholly different.

TABLE XXXVII. *Table of Ellipticities of Femoral Neck.*

	Race	♂ + ♀ Ellipticity		Source of Data
Lemuroids	*Tarsiidae*	58·15 (2)		Pearson and Bell
	Galaginae	68·2 (6)		,,
	Lemurinae	70·5 (18)		,,
	Indrisinae	72·4 (8)	Mean 73·25	,,
	Chiromyrdae	79·75 (2)		,,
	Lorisinae	90·5 (6)		,,
Cebidae	*Hapalinae*	65·2 (16)		Pearson and Bell
	Nyctipithecinae	65·2 (8)		,,
	Pithecia	70·2 (2)		,,
	Brachyurus	72·5 (2)		,,
	Cebus	76·75 (6)	Mean 74·26	,,
	Lagothrix	76·85 (2)		,,
	Ateles	78·8 (4)		,,
	Mycetes	88·55 (2)		,,
Simiadae	*Cercopithecus*	72·0 (8)		Pearson and Bell
	Cynocephalus	74·5 (8)		,,
	Macacus	77·9 (14)	Mean 76·70	,,
	Semnopithecus	79·0 (10)		,,
	Cercocebus	80·1 (4)		,,
	Dryopithecus rhenanus ...	85·1 (1)		Cast
Simiinae	Gorilla	75·5 (21)		Various
	Chimpanzee	75·5 (11)	Mean 75·73	,,
	Orang-utan	76·2 (5)		,,
	Gibbon	80·5 (16)		,,

Race	♂ + ♀ Ellipticity				Source of Data
Pithecanthropus erectus ...	?				—
Homo mousteriensis (Hauseri)	97·9 (1)				Cast
Spy	82·0? (1)			Mean Neanderthal 84·5? (6)	—
Neanderthal	73·6 (1)				Cast
Galley Hill	69·6? (1)				—
Homo aurignacensis (Hauseri)	74·2 (1)				—
Fuegians	83·28 (10)				Hultkrantz
Negroes	81·44 (34)				Bertaux
,, ...	80·15 (12)				Bumüller
Non-adult French	80·82 (17)				Bertaux
	♂		♀		
Paltacalo Indians	80·94 (63)		79·56 (52)		Antony and Rivet
Bolognese	79·8 (20)		79·6 (23)		Zanolli
Guanches	77·64 (48)				Bertaux
French (1st Series)	76·95 (29)		75·40 (17)		,,
French (2nd Series) ...	76·46 (42)				,,
17th century Londoners ...	75·69 (459)		76·92 (350)		Pearson and Bell
Bavarians	75·25 (32)				Bumüller
Dolmens of Lozère	74·00 (5)				Kuhff
Bajuvars from Row Graves	74·01 (24)		76·43 (9)		Lehmann-Nitsche
Swabians and Alemanns from Row Graves ...	72·37 (21)		73·30 (8)		,, ,,
Australians	65·8 (2)		74·25 (2)		Pearson and Bell

there is only a rise of 2 to 3 points in the *mean* values. If, however, we examine the genera in the individual families we find an extraordinary variation, so that the value of the index is almost a generic character. Femora of *Tarsius*, the Lemurs and the *Lorisinae* could be identified by this index alone; and the same is true of the *Hapalinae*, *Cebus* and *Mycetes*, or of *Cercopithecus* and *Cercocebus*. The ranges of the Lemuroids and *Cebidae* cover the whole range of Man, and that of the *Simiadae* at least the range of Recent Man. Even the Recent Gibbon which stands out so markedly from the nearly uniform values of the Greater Anthropoids finds its parallel in *Ateles* (78·8), and *Mycetes* exceeds *Dryopithecus rhenanus*. The high value of the latter suggests that the low value of the Greater Anthropoids may be a decline from a much higher value in their fossil ancestry. This would support the somewhat doubtful high value in Neanderthal Man, and give the protsimio-human a rotund rather than elliptic form of neck. Without this support from the Eppelsheim femur we should have been inclined to discredit the Neanderthal Type high value, and supposed *mean* values for the ellipticity of the neck to have remained fairly constant from *Simiadae* to Recent Man.

There is no very definite type for this character determinable for the Lemuroids, as our knowledge of the Aye-Aye is based solely on two femora. For the *Cebidae* the type lies between *Brachyurus*—only known to us by two femora of a young animal—and *Cebus*. *Macacus* is type for the *Simiadae*, and especially relying on our own measurements, the Chimpanzee for the Greater Anthropoids. Our value for the Chimpanzee is 77·3, in striking agreement with the mean of 20 racial groups of Recent Man, and emphasising again the troglodytic associations of the human femur.

Primogenial Man, as we have already remarked, appears to be somewhat inconclusive. Of the very doubtful Galley Hill value nothing can be said. The Neanderthal femur itself gives a result which is also surprisingly low, but the remaining femora of Neanderthal Type provide such high indices that the average of six is surprisingly high! Hence it is only probable, we cannot say certain, that the Greater Anthropoids are separated by Recent Man from Primogenial Man. Unfortunately we have no data for the Cromagnon Type. As far as our material allows us to judge it would seem that in the ellipticity of the neck the human series runs from the high value of Primogenial Man down to the low value of the Greater Anthropoids, starting with the more primitive races such as Fuegians, Negroes and Indians and concluding with Modern Europeans and their forbears. In this as in several other cases Modern Europeans appear to be nearer to the apes than primitive races. This conclusion is to some extent confirmed by Bertaux's small series of non-adult French, which has a mean approaching that of the Negroes. Probably the flattening of the neck in the ape and in Modern Man arises from different causes, the one flattening can hardly be regarded as a reversion to the other. Still the repeated occurrence of this scission of the primates deserves very careful inquiry.

If we have a paucity of material for the ellipticity of the neck we have still less for the secondary index which compares the size of the head with that of the neck. A good deal more would have been available, if the writers of the French

School had published their absolute values as well as their indices. We have in the usual form:

Lemuroids	58·77
Cebidae	53·64
Simiadae	60·36
Dryopithecus rhenanus ...	59·8
Simiinae	49·12
Neanderthal Type (6) ...	60·2
17th century Londoners ...	55·38

The interpretation of these results is not very easy. The tendency seems to be increase of horizontal diameter of head relative to horizontal diameter of neck. This is exhibited in the *Cebidae* and *Simiinae*, but the intermediate link to the *Simiinae*, the *Simiadae*, in this exceptional case shows a rise, which is surprising. As usual

TABLE XXXVIII. *Table of Secondary Index of the Neck* (*i.e.* 100 × Minimum Horizontal Diameter of Neck / Horizontal Diameter of Head).

	Race	Secondary Index of Neck		
Lemuroids	*Tarsiidae*	53·75	(2)	Mean 58·77
	Chiromyrdae ...	56·75	(2)	
	Indrisinae	58·1	(8)	
	Lemurinae	58·6	(18)	
	Galaginae	60·8	(6)	
	Lorisinae	64·6	(6)	
Cebidae	*Pithecia*	47·85	(2)	Mean 53·64
	Brachyurus ...	50·45	(2)	
	Hapalinae	51·6	(16)	
	Nyctipithecinae ...	52·0	(8)	
	Ateles	52·9	(4)	
	Cebus	54·9	(6)	
	Lagothrix	58·95	(2)	
	Mycetes	60·45	(2)	
Simiadae	*Cynocephalus* ...	54·1	(8)	Mean 60·36
	Cercopithecus ...	58·4	(8)	
	Macacus	60·8	(14)	
	Semnopithecus ...	62·6	(10)	
	Cercocebus	65·9	(4)	

Race	Secondary Index of Neck	
Dryopithecus rhenanus ...	59·8	(1)
Simiinae: Gorilla	54·83	(7)
Gibbon	49·95	(2)
Chimpanzee	48·5	(2)
Orang-utan...	43·2	(5)
Homo mousteriensis (*Hauseri*)	68·6	(1)
Spy	58·9	(1)*
Neanderthal	53·2	(1)
Galley Hill	50·0?	(1)
Homo aurignacensis (*Hauseri*)	53·5	(1)
	♂	♀
17th century Londoners ...	55·23 (370)	55·54 (280)
French Neolithics (calculated on the basis of Manouvrier and Antony's Montigny material)	53·46 (23)	
Australians	50·4 (2)	47·85 (2)

* This is the value obtained by us from the cast. Fraipont and Lohert's measurements provide Spy No. 1: 59·3, Spy No. 2: 64·2, which confirm the view that a high value must be given to the Secondary Index of the neck in Primogenial Man of Type A.

Neanderthal Type shows the reversed tendency, supported in this case as in the last by *Dryopithecus rhenanus*, although the Recent Gibbon exhibits the *Simiinae* fall and is in fact the type anthropoid for this character[1]. Recent Man regresses, as we are accustomed to see, from the Neanderthal Type to a more simian character.

[1] The other types are Lemur proper for the Lemuroids; *Ateles* or *Cebus* for the *Cebidae*, and *Macacus* for the *Simiadae*.

(ix) The Lemotic Index.

Of the absolute measurements of the neck we have said nothing so far, chiefly because authorities by no means agree as to the manner in which the neck should be determined. Further growth in absolute size from Lemuroids through lesser apes to man is obvious and has been sufficiently demonstrated over other characters, if any demonstration were needful. All the cases known to us of Primogenial Man including Galley Hill and *Homo aurignacensis* (*Hauseri*) have short necks—the sole exception being the La Chapelle-aux-Saints femur. *Pithecanthropus erectus* is well within the modern range. If we wish to draw conclusions from *relative* length of neck we may take the ratio of length of neck to oblique length, although at first sight it seems likely that the Secondary Bust Index already discussed contains all the information likely to be obtained in this manner. We find the following results:

Table XXXIX. *Table of Index* (100 × Length of Neck/Oblique Length of Femur).

	Race	Lemotic* Index		
Lemuroids	*Tarsiidae*	4·75 (2)	Mean 6·23	
	Chiromyrdae	5·7 (2)		
	Galaginae	6·2 (6)		
	Lorisinae	6·4 (6)		
	Indrisinae	7·1 (8)		
	Lemurinae	7·25 (18)		
Cebidae	*Hapalinae*	6·6 (16)	Mean 8·56	
	Nyctipithecinae	6·8 (8)		
	Brachyurus	7·3 (2)		
	Pithecia	7·95 (2)		
	Cebus	8·35 (6)		
	Mycetes	9·8 (2)		
	Ateles	10·8 (4)		
	Lagothrix	10·9 (2)		
Simiadae	*Semnopithecus*	7·4 (10)	Mean 8·25	
	Cercopithecus	7·6 (8)		
	Cercocebus	8·1 (4)		
	Macacus	8·8 (14)		
	Cynocephalus	9·35 (8)		
	Dryopithecus rhenanus	10·8 (1)		

	Race	Lemotic Index	
Simiinae	Gorilla (i)	15·87 (7)	
	„ (ii)	[16·43 (14)]	
	Chimpanzee (i)	14·20 (2)	
	„ (ii)	[13·26 (10)]	
	Orang-utan	14·40 (5)	
	Gibbon	9·55 (2)	
	Pithecanthropus erectus	11·39 (1)	
	La Chapelle-aux-Saints	13·22 (1)	11·10 (4)
	Homo mousteriensis (*Hauseri*)	11·46 (1)	
	Spy	11·27 (1)	
	Neanderthal	8·45 (1)	
	Galley Hill	11·25 (1)	
	Homo aurignacensis (*Hauseri*)	11·47 (1)	
	Cromagnon Type	11·1 (5)	
	Grimaldi Type	12·6 (2)	
		♂	♀
	17th century Londoners	12·64 (456)	11·68 (349)
	Modern French	[13·01 (29)	12·56 (17)]
	Australians	12·75 (2)	9·35 (2)

* Greek, λαιμός, the neck. It will be convenient to have a name for this index.

The values in square brackets are deduced from Bertaux's measurements by finding a single reducing factor giving the greatest accordance for the four series; it is 1·24. Bertaux[1] measures the true neck and not the bust. Parsons[2] and Tama-

[1] Bibl. 52, p. 220. His values for length of neck are ♂ 47·11, ♀ 40·92; probably he measures from base of head to trochanteric line.

[2] The results in Parsons' case again emphasise the evil of sexing by selection of small heads or busts, the female lemotic index being suspiciously low. Evangeli-Tramond also gives values for length of "neck," but we have been quite unable to associate his values with anything like the bust less radius of head. They are much too *large* for this. Thus we find from his data ♂ L. 91·65, ♂ R. 86·70, ♀ L. 72·35, ♀ R. 76·60. These values for length of neck vastly exceed any values for the whole length of bust with which we are acquainted. (See Bibl. 65, pp. 82—5.) They approach the entire proximal breadth.

gnini with de Campos[1] have measured the bust but called it the neck, which is misleading. Subtracting half the diameter of the head from their "neck" values and using the same reducing factor as we have found from Bertaux's results, we reach the following values:

Lemotic Index { Portuguese ♂ 11·58 (134), ♀ 11·28 (126)
Rothwell English ♂ 11·22 (178), ♀ 10·49 (105).

It is fairly clear that our factor does not fully compensate for the individual method of measuring the "neck" adopted by these authors, and indeed we have no reason for supposing that Parsons and Tamagnini with de Campos adopted the same method as Bertaux, rather the reverse[2].

We may draw, however, one important result from the 17th century Londoners, the Rothwell English, the modern French and the modern Portuguese—*the neck relative to the absolute size of the femur is smaller in woman than in man.* In Portuguese, Rothwell English and 17th century Londoners the smaller value of the collar angle of the female is far from adequate to produce a visible hip extension in the female compared with the male. For a short series of modern French there is a like smaller value in the female collar angle. Walmsley for another very short series gives an excess of collar angle even in the female, while a long modern French series gives absolute equality in the two sexes[3]. We are thus compelled to accept Charpy's conclusion that relatively larger haunches in the female are not due to the fact that she has a relatively larger femoral neck or a markedly smaller collar angle[4], but arise from her having a relatively broader pelvis.

Summarising in the usual form we have for the Lemotic Index of our families of primates:

Lemuroids	6·23	(Type *Galaginae*)
Cebidae	8·56	(Type *Cebus*)
Simiadae	8·25	(Type *Cercocebus*)
Greater Anthropoids	14·76[5]	(Type Orang)
Neanderthal Type (6)	11·3	
Recent Man (46 racial groups) ...	11·52	
17th century Londoners	12·16	

Alongside these we may put for comparison

Dryopithecus rhenanus	10·8	
Recent Gibbon	9·55	
Ateles	10·8	

indicating again the close resemblance of the femur of *Ateles* to that of the Gibbon.

[1] Bibl. 118.

[2] See footnotes 1 and 2 on previous page.

[3] Bertaux, Bibl. 118.

[4] Charpy for a moderate amount only of material finds ♂ 127°, ♀ 128° for collar angle. But he asserts the existence of two human types and gives 1st Type Mean ♂ = Mean ♀ = 131° and 2nd Type Mean ♂ = Mean ♀ = 122°. Bibl. 36, p. 287 *et seq.*

[5] If we include Recent Gibbon, we have for the *Simiinae* 13·46 which makes the Chimpanzee rather than the Orang the type.

Generally we see great development of the neck relative to the size of the femur from *Tarsius* at 4·75 to Man at 12·2. But here the Greater Anthropoids have outrun even Neanderthal Man, who was in this feature close to the average of Recent Man. We should expect the protsimio-human femur to have a Lemotic Index from 11·5 to 12·2 standing not far from midway between fossil Gibbon 10·8 and Chimpanzee 13·5. We long again to test this result on a fossil Chimpanzee-like femur.

Our table further confirms a conclusion of Rodriguez who, starting with a very different outlook from ourselves, we have yet found a very reliable observer. This conclusion is that the Anthropoids with the exception of the Gibbon have a relatively long femoral neck[1]. Our data suffice to show that Modern Man again separates Primogenial Man from the Anthropoids (excluding the Gibbon). The Galley Hill femur is closer to the average Neanderthal Type than to Modern Man and this appears probable of *Homo aurignacensis* (*Hauseri*). If our value for *Pithecanthropus erectus* be correct the Trinil femur is in this solitary feature closer to Primogenial than to Modern Man, although still within the possible human especially female range, and *à fortiori* further removed from the Greater Anthropoids. We have not adequate material for the determination of the mean Lemotic Index for the Gibbon, but our two cases here as in many other characters do not lend help to Bumüller's view that the Trinil femur is that of a giant Gibbon.

In our table on p. 361 we have given the conventional length of neck, *i.e.* capito-collar axis less radius of head, as deduced by a series of fairly reasonable hypotheses from Rodriguez's data. If we divide these neck lengths by the oblique lengths as given by Rodriguez, we obtain the Lemotic Indices for a number of races. The values for ♂ and ♀ will necessarily be the same owing to the nature of the hypotheses; this conclusion as we have seen is only roughly correct. We have therefore not ventured to place these somewhat hypothetical results in the previous table. While the present table as far as the Europeans are concerned is fairly self-consistent it differs not a little from the other, *i.e.* the diversity of method leads to sensibly diverging results for the same race. It is clear from this table that Negroes, Australasians and the bulk of Asiatics—Japanese and Ainos excluded—have a relatively short femoral neck. These races are hypobrachy-lemotic (below 10·9); the brachy-lemotic (10·9—11·4) are American Indians—some ancient equatorial Indians excluded—the Ancient Egyptians, and the Guanches, closely associated in this as in some other femoral characters with the Cromagnon Type.

In the meso-lemotic group (11·4—11·9) we find besides the Japanese and Aino, the neolithic Bronze Age men and some of the historic forbears of modern Europeans. Modern Europeans and their forbears form the bulk of the dolicho-lemotic group (11·9—12·3), while the hyperdolicho-lemotic (over 12·3) races are the ancient equatorial Indians and probably such primitive peoples as Basques, Maori and Laplanders, our "fringe" races. The table is not without suggestiveness, but it needs substantiating and developing, especially in the direction of differentiating the sexes. This can only be done when a standardised measurement of the neck has been established. But

[1] Bibl. 101, p. 39.

after due consideration we consider the present Lemotic Index has in several respects distinct advantages over the Bust Ratio.

TABLE XL. *Table of the Lemotic Index, based chiefly on deductions from Rodriguez's material.*

Race	Lemotic Index	Race	Lemotic Index
Laplanders	13·0 (6)	Cromagnon	11·5 (13)
Ancient Equatorial Indians ...	12·8 (126)	Negroes (*? locus*)	11·5 (48)
Ancient Bolivians	12·3 (51)	Turks	11·5 (18)
Maori	12·2 (6)	Canary Islanders	11·5 (287)
Basques	12·2 (35)	Berbers and Guanches	11·4 (94)
17th century Londoners	12·2 (805)	Ancient Egyptians	11·4 (22)
Modern French	12·1 (69)	Ancient Venezuelians	11·4 (43)
Modern Germans	12·1 (18)	Patagonians	11·3 (101)
Mediterranean Race (Old and New)	12·0 (32)	Ancient Mexicans	11·3 (22)
Mediaeval French	11·9 (183)	Californian Indians	11·3 (122)
Modern Portuguese	11·9 (260)	Indo-Chinese	11·3 (16)
Veddahs	11·9 (2)	Hindoos	11·1 (18)
Eskimo	11·9 (13)	Polynesians	10·9 (18)
Japanese	11·9 (92)	Phoenicians and Carthaginians ...	10·9 (16)
Ainos	11·8 (8)	Chinese	10·9 (6)
Gauls and Romano-Gauls	11·8 (78)	Neolithic Swiss Dwarfs	10·9 (4)
Ancient Slavs	11·7 (43)	Mozambique Negroes	10·9 (13)
Neolithic Europeans	11·7 (240)	New Guinea Negroes	10·8 (16)
Fuegians	11·7 (12)	Congolese	10·7 (20)
Peruvian Indians	11·7 (75)	Indonesians	10·6 (14)
Bronze Age Europeans	11·6 (46)	Melanesians	10·5 (80)
Franks and Burgundians	11·5 (30)	Malays	10·5 (118)
Merovingians	11·5 (40)	Negritos	10·5 (42)

Recently Walmsley[1] has taken up the problem of the relative size of the neck and formed the Lemotic Index for 30 adults, nine non-adults and one foetus. His definition both of capito-collar axis and of axis of shaft is not in agreement with ours and we believe too vague[2]. However he appears from his figures to be dealing with a measurement on the anterior face of the femur, and we have applied to his numbers the same factor as we obtained from Bertaux's results, so that we can roughly compare them with our own. We reach the following results:

	Lemotic Index
Foetus 5 months	5·7
Birth	5·3
Non-adult 2 years	6·5
,, 4 ,, ...	7·6
,, 5 ,, ...	7·9
,, 8 ,, ...	8·3
,, 10 ,, ...	9·7
,, 14 ,, ...	11·4
,, 16 ,, ...	11·9
,, 18 ,, ...	11·9
Adult ♂ 12·03 (15)	Adult ♀ 12·65 (15)

[1] Bibl. 113, p. 322 *et seq.*

[2] Thus the axis of neck is said to be line bisecting "base line of head" and "lying in the centre of the neck"—whatever that point may be. The axis of the shaft is defined as "extending through the centre of the bone" and it "if prolonged downwards would bisect the intercondylar line at the lower end of femur" (Bibl. 113, p. 321). We do not know what point is the "centre of the bone," or what is "the intercondylar line," although the wording suggests that the latter is unnecessary, as the axis would only bisect it *if* produced.

The adult values are fairly close, considering the differences of methods of measurement used, to those we have given for modern French and 17th century Londoners. On the other hand Walmsley gives a somewhat greater lemotic index for females than for males. Bertaux using two more females and nearly double as many males also indefinitely sexed, *i.e.* dissecting room material, found the exact opposite and all the long series of femora sexed by anatomical appreciation agree in this judgment. We cannot therefore hold Walmsley's slender material to upset this conclusion. Nor are we forced to do so, for a rough estimate gives the standard deviation of this index as about 1·2, leading in a mean based on 15 cases to a probable error of ·31, and accordingly in the case of the difference of two sets of 15 to a probable error of ·44. Thus the difference observed by Walmsley is less than 1·5 times its probable error and is not *significant*. It is another illustration of the danger of short series.

Walmsley's observations of the steady increase of the lemotic index with growth stand on a stronger basis because they are continuously in one sense. They show, however, that the stages of non-adult growth are far from indicating any evolutionary history approximating man to the Greater Anthropoids. They might well represent a Lemuroid to lesser ape evolution.

It would be of some interest to compare the changes in the lemotic index of the Anthropoids during the non-adult period. Neither our result nor Walmsley's suggests —what has been asserted by some anthropologists—that woman is more apelike than man; and our results do not show that woman in this character is *markedly* more "infantile" than man—and *à fortiori* Walmsley's do not; the hypothesis of female infantilism is another of the largely unproven hypotheses of the older anthropological school.

(x) The Epiphysial Ratio and Capito-bicondylar Index.

The remaining characters which we propose to deal with in this section, the Epiphysial Ratio and the Capito-bicondylar Index already discussed on pp. 348—9, link together the proximal and distal epiphyses. Having discarded the proximal breadth as of too uncertain a character to be of fundamental service, we considered the Capito-collar Axis or length of the bust to be the best representative of the magnitude of the proximal epiphysis, and its ratio to the Bicondylar Width the most satisfactory index by which to measure the relative magnitude of the proximal and distal epiphyses. Unluckily our material is limited in two ways. First because an accurately defined bust length has rarely been included among the hitherto published femoral measurements and secondly because one or two recent writers who have had fairly long series to study have dropped the old established Bicondylar Width and replaced it by a new measurement, *i.e.* that of the distal articular surface. Unfortunately Rodriguez who has clearly measured the length of bust[1] as we have done, or very closely as we have done, has published no measurements at all on the distal epiphysis. Hence for this epiphysis we lose his aid which has so often been of service

[1] Rodriguez does not give the bust length, but he does give the Oblique Length and Secondary Bust Ratio, so that something like the bust length can be computed from what he does give: see our pp. 350, 361—3.

in helping out the otherwise scant supply of comparative material. Hepburn gives the Bicondylar Width of a number of races, but not the length of bust. We have ventured to combine for a few races Hepburn's value of the Bicondylar Width with Rodriguez's value of the bust length, but these results must be viewed with great suspicion, not only on account of the fact that the measurements have been made on different groups of individuals, but also because they depend in many cases on a few isolated bones. They are in the following table indicated by square brackets. The first

TABLE XLI. *Table of Epiphysial Ratio.*

	Race	Epiphysial Ratio		Race	Epiphysial Ratio
Lemuroids	*Chiromyrdae*	65·9 (2)	Mean 75·6	*Pithecanthropus erectus* ...	94·9 (1)
	Tarsiidae	70·25 (2)			
	Galaginae	70·4 (6)		La Chapelle-aux-Saints ...	98·2? (1)
	Lorisinae	71·3 (6)		*Homo aurignacensis* (*Hauseri*)	92·0 (1)
	Lemurinae	86·4 (18)		Galley Hill	82·0?? (1)
	Indrisinae	90·9 (8)		Spy	81·4 (1)
Cebidae	*Nyctipithecinae* ...	72·8 (8)	Mean 83·21	*Homo mousteriensis* (*Hauseri*)	80·4 (1)
	Hapalinae	73·4 (16)		Neanderthal	72·0 (1)
	Cebus	80·3 (6)			
	Lagothrix	80·85 (2)		Laplanders	[106·9 (4 + 6)]*
	Mycetes	84·25 (2)		Australians	101·65 (2) 83·6 (2)
	Pithecia	85·05 (2)		Fuegians	[97·9 (5 + 12)]†
	Brachyurus	86·9 (2)		Maori‡	97·7 (5)
	Ateles	102·1 (4)		17th century Londoners ...	96·88 (306) 96·22 (201)
Simiadae	*Cercopithecus*	76·25 (8)	Mean 82·90	Guanches	[95·4 (2 + 94)]*
	Semnopithecus ...	80·5 (10)		Eskimos	[95·4 (4 + 13)]*
	Macacus	81·6 (14)		Veddahs	[95·3 (2 + ?)]§
	Cynocephalus	87·3 (8)		Negritos	[93·4 (42 + ?)]§
	Cercocebus	88·85 (4)		Negroes	[90·7 (9 + 48)]*
				Japanese, 1st Series ...	[87·8 (92 + ?)]§
	Dryopithecus rhenanus	105·6 (1)		Hindoos	[86·9 (6 + 18)]*
				Japanese‖, 2nd Series ...	86·5 (20) 86·7 (20)
Simiinae	Gibbon	103·05 (2)	Mean 93·10	Ainos‖	86·4 (40) 86·7 (22)
	Gorilla	91·7 (7)		Chinese	[83·9 (2 + 6)]*
	Chimpanzee	90·0 (2)		Malays	[82·4 (118 + ?)]§
	Orang-utan	97·6 (5)			

Mean Neanderthal (6) 83·0

* Deduced from combining material of Rodriguez and Hepburn.

† Deduced from combining material of Rodriguez and Martin.

‡ Mollison.

§ Deduced from combining material of Rodriguez and Mollison.

‖ Koganei, but his capito-collar axis differs somewhat from ours. The measurements, however, accord with those of the 1st Series of Japanese.

of the accompanying numbers in the round brackets signifies the number of cases for the Bicondylar Width, the second that for the bust length. Both sexes are in these instances combined as Rodriguez gives us no means of distinguishing between the two. This adds to the doubtful character of these tabled values, as although the indices may be the same for the two sexes, we have had to deduce absolute values before we could proceed to a new index, and we could only do this on the assumption of equality

in the two sexes, which may possibly be approximately true in Rodriguez's cases, but is not true in Hepburn's.

Summary of results for Epiphysial Ratio of the primate families:

Lemuroids	75·86	(Type *Lorisinae*)
Cebidae	83·21	(Type *Pithecia*)
Simiadae	82·90	(Type *Macacus*)
Greater Anthropoids	93·10	(Type Gorilla)
Neanderthal Type (6)	83·0	
[Galley Hill	82·0 ? ?]	
Cromagnon Type (5)	92·3	
Grimaldi Type (2)	94·5	
[Recent Man (18 racial groups) ...	91·84]	
17th century Londoners	96·55	

It will thus be seen that from the Lemuroids upwards the tendency has been for increase of the proximal relative to the distal epiphysis. The Gibbons are side tracked in their exaggerated value, although the slender data for Laplanders and Australians show like human values:

Dryopithecus rhenanus	105·6
Recent Gibbon	103·05
Ateles	102·1

Ateles as usual following the Gibbon and diverging widely from all the other *Cebidae*. The ascent is very marked up to the Greater Anthropoids. Then comes a reversion to the *Simiadae* level with man of the Neanderthal Type, but the increase again goes on through Cromagnon and Grimaldi up to our 17th century Londoners.

The value of the Epiphysial Ratio for the La Chapelle-aux-Saints femur is disturbing, but that value is itself doubtful. We are inclined to hold, however, that Primogenial Man of the Neanderthal Type had compared with Modern Man a proximal epiphysis small as compared to the distal. Thus Recent Man has again relative to Neanderthal Man reverted to more anthropoid proportions. The more than doubtful Galley Hill result associates this femur more closely with the Neanderthal Type than with Modern Man, and if it had been reliable would have differentiated it from *Homo aurignacensis* (*Hauseri*) which falls into the Modern Man range. *Pithecanthropus erectus* is absolutely human, and, despite Bumüller's judgment, is differentiated from our specimens of the Gibbon more than from any other ape. Of the range of Modern Man it is impossible to say much, but the order suggested—far indeed from established by such data—is: certain "fringe" folk, modern Europeans, Negroes, Asiatics, the latter being closest to the Neanderthal Primogenial Type.

A less satisfactory measure of the relative proportions of the two epiphyses may be obtained from the Capito-bicondylar Index. Here again we are met by the same difficulty—osteologists seem to have a preference for either proximal or distal epiphysis and rarely provide adequate measures of both. A table of the Capito-bicondylar Index has been given in Table XXX, p. 348, of this paper. It will be seen on examining

that table that the conclusions to be drawn are not identical with those from the table of the Epiphysial Ratio. The proportion of femoral head to bicondylar width is clearly not the same as that of neck to bicondylar width. The proportions in which neck and head divide the bust vary widely in the various races. Modern Man in Capito-bicondylar Index dichotomises the ape series. The Neanderthal Type has a high proportion of head to bicondylar width but probably a low proportion of bust to bicondylar width. In the former it exceeds the Anthropoids and Recent Man, in the latter it falls short of them. Fuegians and Maori stand high in the Epiphysial Ratio and low in the Capito-bicondylar Ratio. It is possible that a compensatory principle exists and that a large development of the head takes place at the cost of the neck. At any rate the evolutions of head and neck have not been proportional. But more material must be available before any really safe conclusions can be formed. Both Epiphysial Ratio and Capito-bicondylar Index are probably of value, but the former, judging merely from our present slender data, seems likely to prove more suggestive.

(xi) *Concluding Remarks.* As in the case of the General Indices and the Special Indices of the Shaft we now provide a table giving the characters for the proximal

TABLE XLII. *Characters of the Proximal Epiphysis of the Hypothetical Protsimio-human.*

Character	Recent Gibbon	Protsimio-human	Recent Chimpanzee	Recent Man
Vert. Diameter of Head ...	15·0	36·0	36·15	43·92
Horiz. Diameter of Head ...	15·1	35·8	36·2	43·54
Min. Horiz. Diam. of Neck ...	7·55	19·7	17·6	24·14
Min. Vert. Diam. of Neck ...	10·0	25·2	22·7	31·74
Capito-collar Length	26·05	51·5	62·4	72·50
Length of Neck	18·5	33·5	46·3	50·54
Robusticity of Head	15·55	22·3	23·2	20·60
Ellipticity of Head	100·7	99·4	100·15	98·98
Ellipticity of Neck	75·7	78·0	77·3	76·30
Secondary Index of Neck ...	49·95	55·0	48·5	55·38
Lemotic Index	9·55	10·4	14·2	11·87
Head-Bust Ratio	58·15	69·9	58·0	61·01
Primary Bust Ratio	13·4	15·8	19·8	16·95
Secondary Bust Ratio ...	13·4	16·0	20·1	17·06
Bust Shaft Index	14·85	19·0	24·3	20·05
Capital Ratio	7·75	11·1	11·5	10·26
Capito-bicondylar Ratio ...	59·4	58·1	52·2	58·62
Epiphysial Ratio	103·05	83·1	90·0	96·55
Collar Angle	114°·5	120°·5	133°·3	130°·4

epiphysis of our hypothetical Protsimio-human. We have obtained these by considering each index in turn, giving weight to the drift of development in *Simiadae*, *Simiinae* and Primogenial Man. At times it almost seemed to us that the branch-point of the *Cebidae* might for certain characters have even more suggestiveness than that of the *Simiadae*, but we did not venture to follow up any hint we seemed to discover in this

sense. In selecting our indices—which are of course only round values—occasionally some latitude was possible; but not infrequently we were driven almost at once to a very small range of possible values. What impressed itself upon us when the values were obtained and recorded alongside those of Recent Man based on a mean of the two sexes, is how closely our hypothetical bone lies between the chimpanzee and the human femur. Prot-simio-human, Recent Chimpanzee and Recent Man present on the whole an association in marked contrast to the Recent Gibbon. There are certain gibbonlike characters in the protsimio-human femur, *e.g.* its Lemotic Index and Bust Ratios, but on the whole it is not hylobatic but troglodytic, and what is more its troglodytism is often nearer that of Recent Man than of the Recent Chimpanzee. Thus it is quite possible that the "missing link" when found will be considerably more human than, say, gorilloid—a point which we shall discuss more at length in Chapter X.

CHAPTER IX

CHARACTERS OF THE DISTAL EPIPHYSIS

CONTENTS

		PAGE
(i)	Introductory	387
(ii)	Bicondylar Width and Bicondylar Ratio	389
(iii)	The Condyles: Measurements taken and suggested: Band-radial Indices	394
(iv)	Absolute Lengths of Condyles	400
(v)	Condylar Lengths Indices	406
(vi)	The Condylar Indices	411
(vii)	The Condylar Trochanteric Index: Condylar Femoral Length Ratios	414
(viii)	Condylar Obliquity Index and Condylar Obliquity	420
(ix)	Study of the Femoral Articular Surface of the Knee-joint	424
	A. Absolute size: Distal Articulation Width and Patellar Surface Height	424
	B. Indices: (*a*) Distal Articulation Ratio	426
	(*b*) Distal Articulation Index	427
	(*c*) Rotular Ratios	428
	(*d*) Rotular Index	429
	C. General Points as to Distal Articulation	431
(x)	Concluding Remarks on the Distal Epiphysis	432
	Characters of the Distal Epiphysis of the Hypothetical Prot-simio-human	432
(xi)	Examination of the Dwarf Femur	433
	(*a*) Femoral Angles	436
	(*b*) General Indices	436
	(*c*) Indices of the Shaft	437
	(*d*) Indices of the Proximal Epiphysis	439
	(*e*) Indices of the Distal Epiphysis	441
	(*f*) Conclusions	444

(i) *Introductory.*

Unfortunately for the Distal Epiphysis we lose the help of the chief French writers, who have so far contributed largely to our comparative study of femoral characters. With rare exceptions the French seem to have avoided the study of the lower end of the femur. Antony (with Rivet) and Bertaux give the bicondylar width for some of the anthropoids, but not as far as we are aware for man. Rodriguez fails us entirely, and not one of the writers on neolithic man in France has paid attention to the condyles. In England matters are as bad; putting aside Flower and Garson whose studies on the femora of prehistoric and primitive man are of no importance from present day standards, we note that Scott with his unique collection of Moriori and Maori femora has given no measurements of the distal

epiphysis. Parsons has given us only the breadth of the distal articulation[1]. Thus up to the present the distal epiphysis has been chiefly studied and that not very amply by the Germans. The two anthropologists who have given it most attention are Bumüller and Klaatsch. Both are on this point suggestive but their conclusions are not of any great validity. Klaatsch, because here, as elsewhere, he thinks he can argue as to races by giving the measurements of one or two selected individual bones—wholly disregarding the large variations within a race. Bumüller because with apparently ample material he contents himself with measuring small portions of it. Neither show any knowledge of the probable errors of short series, or recognise that even if they dealt with two series of fifty femora, these might, especially if due regard

[1] In order to form some idea of the bicondylar width of the Rothwell and Portuguese femora we have formed the regression equations for our London material of bicondylar width on maximum length and on vertical diameter of head, both these characters having high correlations with the bicondylar width. These equations are as follows:

♂ R.: Mean bicondylar width = 32·03 + ·1077 × Mean Maximum Length,
♂ L.: Mean bicondylar width = 37·03 + ·0951 × Mean Maximum Length,
♀ R.: Mean bicondylar width = 44·39 + ·0628 × Mean Maximum Length,
♀ L.: Mean bicondylar width = 36·695 + ·0813 × Mean Maximum Length,

and again: ♂ R.: Mean bicondylar width = 30·94 + 1·0456 × Mean Vertical Diameter of Head,
♂ L.: Mean bicondylar width = 26·50 + 1·1312 × Mean Vertical Diameter of Head,
♀ R.: Mean bicondylar width = 30·89 + ·9540 × Mean Vertical Diameter of Head,
♀ L.: Mean bicondylar width = 23·79 + 1·1308 × Mean Vertical Diameter of Head.

We have:

	Mean Length		Mean Vertical Diameter of Head	
	Rothwell English[1]	Modern Portuguese[2]	Rothwell English[3]	Modern Portuguese[4]
♂ R.	456·25	448·06	49·13	46·64
♂ L.	460·05	447·82	49·15	46·53
♀ R.	418·09	406·11	42·74	40·67
♀ L.	421·94	403·81	42·14	40·25

[1] Bibl. No. 118, p. 18. [2] Bibl. No. 118, p. 19.
[3] As determined by us. [4] Bibl. No. 118, p. 24.

From these we deduce by the above equations:

Bicondylar Width.

	Rothwell English			Portuguese		
	From Maximum Length	From Vertical Diameter of Head	Mean of Preceding Values	From Maximum Length	From Vertical Diameter of Head	Mean of Preceding Values
♂ R.	81·17	82·31	81·74 [76·57]	80·29	79·71	80·00 [74·81]
♂ L.	80·78	82·10	81·44 [76·91]	79·62	79·13	79·38 [74·68]
♀ R.	70·65	71·67	71·16 [67·33]	69·89	69·69	69·79 [65·83]
♀ L.	71·00	71·44	71·22 [67·48]	69·52	69·30	69·41 [65·56]

The quantities in square brackets are the widths of the distal articulation. We do not wholly agree with Parsons' own means, 75, 77, 68 and 67 respectively.

We see from these results that the mean differences of the bi-epicondylar width and the width of the articulation of the distal epiphysis as taken by Parsons are

♂ R. 5·2, ♂ L. 4·6, ♀ R. 3·9, ♀ L. 3·8,

or say roughly 5 mm. for a male and 4 mm. for a female bone. We have used the reconstructed values given above in our tables, so as to include the Rothwell English and the Portuguese.

were paid to sex and side, be inadequate for the determination of racial differences. Nevertheless their discussions will remain highly suggestive for further biometric work as longer series are collected and measured. We commence our discussion with the absolute and relative sizes of the bicondylar width.

(ii) *Bicondylar Width and Bicondylar Ratio.*

The table on the following page contains all the data we have been able to collect as to the bicondylar width.

We extract the following summary:

Lemuroids	13·53
Cebidae	19·92
Simiadae	29·34
Dryopithecus rhenanus[1] ...	41·1
Greater Anthropoids ...	69·61
Neanderthal Type (6) ...	87·6
Galley Hill	[88·0 ??]
Cromagnon Type (5) ...	92·7
Grimaldi Type (2)	93·0
Recent Man (Racial Mean) ♂ 79·57 (30) ♀ 69·90 (24)	
,, ,, (Racial Mean) ♂+♀ 74·73	
17th century Londoners ♂ 79·76, ♀ 70·00	
,, ,, ,, ♂+♀ 74·88	

We see that our 17th century Londoners serve extremely well as type for this character in Recent Man. The usual feature is present—if anything more emphasised in the absolute size of the distal epiphysis—*i.e.* the continuous rise up to the Cromagnon Type and then the rapid fall to Recent Man, who has again become more apelike.

The type forms are the *Lorisinae* for the Lemuroids, *Brachyurus*, or since our specimen was young, probably better *Cebus* for the *Cebidae*, *Cercocebus* for the *Simiadae*, and the Chimpanzee for the Greater Anthropoids.

Before we proceed to a more detailed discussion of Table XLIII something must be said about the construction of the table. We are really responsible for the bulk of the entries having calculated the means when they have not been given or when given recalculated them. The numbers in square brackets are the probable values for either sex when the intermediate mean value is that for pooled sexes. We obtained these as follows: The sex ratios of female ($\bar{x}_f$) to male ($\bar{x}_m$) mean were taken in five long series and the mean of these five values taken as the true sex ratio. For Bicondylar Width $\bar{x}_f/\bar{x}_m = \cdot 8841$ and for Bicondylar Ratio $\bar{x}_f/\bar{x}_m = \cdot 9651$. Hence we deduce on the hypothesis of equality in number of the sexes:

$$\left.\begin{aligned} \bar{x}_f &= \cdot 9385\ \bar{x}_{m+f} \\ \bar{x}_m &= 1\cdot 0615\ \bar{x}_{m+f} \end{aligned}\right\} \text{ for Bicondylar Width.}$$

$$\left.\begin{aligned} \bar{x}_f &= \cdot 9822\ \bar{x}_{m+f} \\ \bar{x}_m &= 1\cdot 0178\ \bar{x}_{m+f} \end{aligned}\right\} \text{ for Bicondylar Ratio.}$$

Of course these will only give for small series rough approximate values.

[1] Recent Gibbon 28·60, *Ateles* 32·9. The Recent Gibbon is seen as a degenerate form of its fossil predecessor, and it is even more slender than *Ateles*.

TABLE XLIII. *Table of Bicondylar Widths.*

	Race	Bicondylar Width		Source
Lemuroids	*Tarsiidae*	6·9 (2)	Mean 13·53	Pearson and Bell
	Galaginae	8·5 (6)		,,
	Lorisinae	12·0 (6)		,,
	Indrisinae	17·5 (8)		,,
	Lemurinae	17·7 (18)		,,
	Chiromyrdae	18·6 (2)		,,
Cebidae	*Hapalinae*	10·1 (16)	Mean 19·92	Pearson and Bell
	Nyctipithecinae	13·0 (8)		,,
	Pithecia	16·8 (2)		,,
	Cebus	18·95 (6)		,,
	Brachyurus	19·9 (2)		,,
	Lagothrix	22·0 (2)		,,
	Mycetes	25·7 (2)		,,
	Ateles	32·9 (4)		,,
Simiadae	*Cercopithecus*	22·6 (8)	Mean 29·34	Pearson and Bell
	Macacus	29·0 (14)		,,
	Semnopithecus	29·0 (10)		,,
	Cercocebus	29·5 (4)		,,
	Cynocephalus	36·6 (8)		,,
	Dryopithecus rhenanus	41·1 (1)		Cast
	Gorilla	85·12 (33)	Mean 69·61	Antony & Rivet / Hepburn, Authors
	Chimpanzee	65·72 (22)		Antony & Rivet / Hepburn, Authors
	Orang-utan	58·00 (3)		Hepburn, Authors
	Gibbon	28·60 (17)		Antony & Rivet / Hepburn, Authors
	Pithecanthropus erectus	78·0 (1)		Photographs
	Neanderthal	89·6 (1)	Neanderthal Type (6) 87·6	Cast
		87 (1)		Schaaffhausen
	Spy	93·6 (1)		Cast
		90 (1)		Fraipont & Lohest
	Homo mousteriensis (Hauseri)	83·3? (1)		Cast

Race	Bicondylar Width	Source
La Chapelle-aux-Saints	84·0?	Photographs
Galley Hill	(88·0??)	Mere appreciation from cast
Homo aurignacensis (Hauseri) ...	86·0	Photographs
	♂ ♀	
Ancient Persians (Anau) ...	87·5 (2) ♂?	Mollison
Fuegians (1st Series)	[85·63] 80·67 (9) [75·71]	Hultkrantz
Swiss Alemanns	83·4 (c. 88) 74·0 (c. 88)	Schwerz
Modern British	83·29 (33) 76·33 (3)	Hepburn
East Indians	82·88 (8) 66·50 (2)	,,
Bolognese	82·7 (20) 74·1 (23)	Zanolli
Romano-British	82·33 (3) —	Hepburn
Modern Swiss (1st Series) ...	82·0 (?)	Martin
Rothwell English	81·59 (174) 71·18 (105)	Parsons
Eskimo	81·50 (2) 69·75 (2)	Hepburn
Australians (1st Series)	81·00 (5) 69·67 (3)	Prochownick
Modern Swiss (2nd Series) ...	80·9 (22) ?♂	Schwerz
Modern Bavarians	80·85 (346) [71·48] (?)	Bumüller
Bajuvars, Swabians, Alemanns from Row Graves	80·06 (16) 72·67 (3)	Lehmann-Nitsche
Maori (1st Series)	79·94 (8) 73·83 (3)	Hepburn
Australians (2nd Series) ...	79·85 (2) 70·6 (2)	Pearson and Bell
17th century Londoners ...	79·76 (319) 70·00 (216)	,,
Modern Portuguese	79·69 (144) 69·60 (126)	Tamagnini and de Campos
Fuegians (2nd Series)	[79·6] 75·0 (5) [70·39]	Martin
Chinese	79·50 (2) —	Hepburn
Japanese	79·4 (20) 71·5 (20)	Koganei
Laplanders	79·00 (2) 65·00 (2)	Hepburn
Negroes (Various)	78·80 (10) 72·00 (3)	,,
Aino	78·6 (36) 71·5 (22)	Koganei
Australians (3rd Series) ...	77·45 (12) 60·75 (2)	Hepburn
Fijians (Viti)	75·83 (24) 69·00 (7)	Prochownick
Caroline Islanders	75·00 (8) 67·00 (4)	,,
Guanches	75·00 (2) —	Hepburn
Maori (2nd Series)	[74·09] 69·8 (5) [65·51]	Mollison
Bushmen	72·50 (2) —	Hepburn
Andamans	67·38 (8) 62·33 (3)	,,
Neolithic Swiss Dwarfs	67·7 (3)	Schwerz

The numbers in the table are in the bulk of cases so few, that this combined with differences of locality, of methods of measurement, of standard for rejection of cases of damaged epicondyles, and *probably of manner of sexing*, causes those cases for which we have two series to appear in widely divergent positions in the table. We have hesitated to screen these divergences by pooling such remarkably different values as those given by Hultkrantz and Martin for Fuegians, by Prochownick and Hepburn for Australians and by Hepburn and Mollison for Maori! Results of but small value can be deduced from this table of absolute size of the distal epiphysis.

The gorilla is the only ape with a distal epiphysis sensibly greater than that of Recent Man, and in absolute size he separates Primogenial from Recent Man. The Galley Hill value of the Bicondylar Width depends on mere appreciation from the cast, but it was a careful appreciation. If any weight can be given to it, this appreciation confirms the conclusion we have drawn from other characters also, that the Galley femur is closer to the Neanderthal Type than to Recent Man. The considerable differences in Bicondylar Width as we have determined them from the casts and as they have been measured on the originals in the case of the Neanderthal femur by Schaaffhausen and of the Spy femur by Fraipont and Lohest point either to considerable changes with the setting of the plaster of Paris, in cast or mould, or to marked differences in mode of measurement or again to instrumental errors. Modern British (?Scotch), Rothwell English, and Modern Swiss are nearer to Primogenial Man of the Neanderthal Type than Prochownick's Australians, and *all* Modern Europeans are interposed between this type of Primogenial Man and Hepburn's Australians. In this feature as in so many others we fail to find those links between the Australian aborigines and Primogenial Man which some authorities have emphasised. Certainly on the basis of absolute size of the distal epiphysis there is nothing to show any close relationship between Modern Primitive Man and Primogenial Man of the Neanderthal Type.

With the exception of two short and doubtful series of great Bicondylar Width, the upper part of the table so far as Recent Man is concerned consists roughly of Modern Europeans and their progenitors, then follow the Asiatics and Negroes, while the femora of small distal epiphysis belong to "fringe" races represented by series sadly deficient in numbers. Divergence of method and smallness of series render it impossible to place in their true position such essentially important races as Fuegians, Eskimo, Laplanders and Maori. *Pithecanthropus erectus* as usual is purely human.

If we turn now to the relative size of the distal epiphysis as measured by the Bicondylar Ratio conclusions of greater value can be drawn. In comparing Klaatsch's Proximal Breadth Ratio based on the trochanteric length (p. 234) we have already given a partial table of the Bicondylar Ratio. We did this to demonstrate that nothing was gained by using the trochanteric in place of the maximum length of the femur. The present table is more complete. In forming it we have recalculated the bulk of the indices from the data provided in the sources indicated or rather in the majority of cases calculated them for the first time. We have further where needful reconstructed maximum length from oblique length and used our own judgment as to other points

of correction and modification. Thus the "source" column of the table by no means denotes that the authors cited are in any way responsible for the indices given.

This table of relative size is clearly more self-consistent than the previous one for absolute size. Where we have two series of the same race, or series of closely allied races, their position is far nearer, and the general serial order is from the evolutionary standpoint far more satisfactory. Galley Hill, if we can give any weight to its index, falls well into the Neanderthal group. *Homo aurignacensis* (*Hauseri*) and *Pithecanthropus erectus* fall into the lower part of the modern human group. *Pithecanthropus erectus* is quite as much like the Andaman as he is like the Gibbon. Gibbon excepted, the Greater Anthropoids head the serial order; then follows Primogenial Man of the Neanderthal Type; then come Japanese, Aino and Chinese, with Eskimo and Fuegians; then the Modern Europeans with their antecedent races[1] and finally Fijians, Australians and Maori.

The summary for the Bicondylar Ratio of the Primates is as follows:

Lemuroids	13·46 (Type *Lemurinae*)
Cebidae	15·36 (Type *Hapalinae*)
Simiadae	15·29 (Type *Cercopithecus*)
Dryopithecus rhenanus	14·3
Gibbon	14·08
Ateles	14·8
Greater Anthropoids	22·52 (Type Orang[2])
Neanderthal Type (6)	20·8
Galley Hill	[20·8 ? ?]
Cromagnon Type	18·4
Grimaldi Type	19·0 ?
Recent Man (Racial Mean)	♂ 17·99 (30) ♀ 17·32 (26)
,, ,, ,, ,,	♂+♀ 17·65
17th century Londoners	♂ 17·83 ♀ 17·25
,, ,, ,,	♂+♀ 17·54

Again we see that our 17th century Londoners are very close to type for Recent Man. All the usual features occur. *Cebidae* and *Simiadae* both increase in index on the Lemuroids and this confirms the view that the *Cebidae* did not depart from the main line of descent—as Haeckel has it—before the Lemuroid stage. The Gibbon group is seen as side tracked on the way to the Greater Anthropoids. The Neanderthal Type has less relative size of distal epiphysis than the Anthropoids—a more Chimpanzee-like proportion. Thence we descend by Cromagnon to Recent Man, who while very divergent from the Gibbons stands between the *Simiadae* and the Greater Anthropoids.

[1] A bad exception occurs in the femora from the German Row Graves. We attribute this entirely to the paucity of the numbers and to our being unable to associate individual bicondylar widths with individual maximum lengths.

[2] The type of the *Simiinae* if we had included *Hylobates* would again have been the Chimpanzee.

TABLE XLIV. *Table of the Bicondylar Ratios.*

	Race	Bicondylar Ratio		Source
Lemuroids	*Tarsiidae*	10·75 (2)	Mean 13·46	Pearson and Bell
	Indrisinae	11·6 (8)		,,
	Lemurinae	13·7 (18)		,,
	Galaginae	14·35 (6)		,,
	Chiromyrdae	14·95 (2)		,,
	Lorisinae	15·4 (6)		,,
Cebidae	*Brachyurus*	12·8 (2)	Mean 15·36	Pearson and Bell
	Pithecia	12·95 (2)		,,
	Nyctipithecinae	14·7 (8)		,,
	Ateles	14·8 (4)		,,
	Hapalinae	15·3 (16)		,,
	Cebus	15·85 (6)		,,
	Mycetes	16·9 (2)		,,
	Lagothrix	19·65 (2)		,,
Simiadae	*Cercocebus*	13·45 (4)	Mean 15·29	Pearson and Bell
	Semnopithecus	14·6 (10)		,,
	Cercopithecus	15·8 (8)		,,
	Cynocephalus	15·9 (8)		,,
	Macacus	16·7 (14)		,,
Dryopithecus rhenanus ...		14·3 (1)		Cast
Gorilla		23·92 (33)		Antony & Rivet / Hepburn, Authors
Orang-utan		22·10 (3)		Hepburn, Authors
Chimpanzee		21·55 (22)		Antony & Rivet / Hepburn, Authors
Gibbon		14·08 (17)		Antony & Rivet / Hepburn, Authors
Pithecanthropus erectus ...		17·4 (1)		Photographs
Neanderthal		20·1 (1)		Cast
		19·9 (1)		Schaaffhausen
Spy		21·8 (1)		Cast
		21·4 (1)		Fraipont & Lohest
Homo mousteriensis (Hauseri)		21·7 ? (1)		Cast

Race	Bicondylar Ratio				Source
La Chapelle-aux-Saints ...	19·5 (1)				Photographs
Galley Hill	20·8 ?? (1)				Mere appreciation from cast
Homo aurignacensis (Hauseri)	17·6 (1)				Photographs
	♂		♀		
Laplanders	19·54	(2)	17·94	(2)	Hepburn
Japanese	19·42	(20)	18·83	(20)	Koganei
Fuegians (1st Series) ...	[19·34]	19·00 (9)	[18·66]		Hultkrantz
Aino	19·28	(36)	18·71	(22)	Koganei
Chinese	19·14	(2)	—		Hepburn
Eskimo	18·81	(2)	16·47	(2)	,,
Fuegians (2nd Series) ...	[18·57]	18·25 (5)	[17·93]		Martin
Caroline Islanders	18·39	(8)	16·57	(4)	Prochownick
Bolognese	18·35	(20)	18·05	(23)	Zanolli
Ancient Persians (Anau) ...	18·34	(2)	—		Mollison
Romano-British	18·14	(3)	—		Hepburn
British	18·02	(33)	17·80	(3)	,,
Modern Bavarians	17·97	(346)	[17·34]		Bumüller
Modern Swiss (1st Series) ...	17·96	(?)	[17·33]		Martin
Neolithic Swiss Dwarfs ...	17·96 (3)				Schwerz
Modern Swiss (2nd Series)...	17·94	(22)	[17·31]		,,
Swiss Alemanns	17·94	(c. 88)	17·52	(c. 88)	,,
17th century Londoners ...	17·83	(313)	17·25	(211)	Authors
Rothwell English	17·81	(174)	16·95	(105)	Parsons
Modern Portuguese... ...	17·79	(144)	17·19	(126)	Tamagnini and de Campos
Maori (1st Series)	17·76	(8)	17·81	(3)	Hepburn
[Australians (1st Series) ...	17·65	(2)	17·65	(2)	Pearson and Bell]
Andamans	17·62	(8)	16·95	(3)	Hepburn
Maori (2nd Series)	[17·55]	17·24 (5)	[16·93]		Mollison
Fijians (Viti)	17·49	(24)	17·10	(7)	Prochownick
Bushmen	17·31	(2)	—		Hepburn
Australians (2nd Series) ...	17·19	(5)	16·36	(3)	Prochownick
East Indians	17·14	(8)	16·36	(2)	Hepburn
Bajuvars, Swabians and Alemanns from Row Graves	16·99	(16)	17·61	(3)	Lehmann-Nitsche
Negroes (Various)	16·93	(10)	16·70	(3)	Hepburn
Guanches	16·54	(2)	—		,,
Australians (3rd Series) ...	16·49	(12)	14·72	(2)	,,

On the whole the table seems so satisfactory considering the slenderness of the data, that we would urge femoralogists to give the Bicondylar Ratio, wherever the state of the epicondyles permits. We should like to see the position of the Negroes more adequately established, to find the Guanches removed from their present anomalous position—worthless for it depends on the two femora of one skeleton—and to ascertain the serial position of Malays, Polynesians, Melanesians and American Indians. This ought to be possible by aid of the ample material in Paris, and we specially commend this problem to our Parisian colleagues.

It may not be without service to institute a terminology for this index and we suggest:

Hyperdolichothemeliotic over 20, Greater Anthropoids and Primogenial Man.
Dolichothemeliotic over 18·75 but less than 20, Japanese, Aino, Chinese, Eskimo and Laplanders.
Mesothemeliotic over 17·75 to 18·75, Modern Europeans and their forbears.
Brachythemeliotic over 17·0 to 17·75, Fijians, Andamans and Bushmen.
Hypobrachythemeliotic below 17·0, Negroes and Australians and Lesser Apes.

It may be desirable to modify the exact ranges when more data are available, but for the present the above limits seem to express fairly rounded classes. We see as for a number of other characters the central position of the higher races, while the Greater Anthropoids with Primogenial Man and the Lesser Apes with Primitive Modern Man form the flanks.

(iii) *The Condyles: Measurements taken and suggested: Band-radial Indices.*

(*a*) Before we consider the condylar indices it is desirable to ascertain what material we have at present available for the absolute condylar lengths[1]. These lengths are fourteen in all, of which we have ourselves rejected eight and only ascertained six namely those marked in the list below with an asterisk.

Lateral Condyle	*Mesial Condyle*
1. Maximum or Natural Length*.	2. Maximum or Natural Length*.
3. Oblique Length or Projection* of (1) on Sagittal Plane.	4. Oblique Length or Projection* of (1) on Sagittal Plane.
5. Maximum transverse Breadth.	6. Maximum transverse Breadth.
7. {*a*. Anterior Arc of Articular Surface. {*b*. Posterior Arc of Articular Surface.	8. {*a*. Anterior Arc of Articular Surface. {*b*. Posterior Arc of Articular Surface.
9. Vertical Band-Radius*.	10. Vertical Band-Radius.
11. Horizontal Band-Radius*.	12. Horizontal Band-Radius.

From these a great variety of indices may be obtained. Clearly any femoralogist who has a series of 800 to 900 femora to deal with must make a selection from these

[1] Bertaux (Bibl. 52, p. 199) has a measure of the internal condyle which he terms the "Encoche condylienne." He defines it as follows:

Mesure de l'encoche du condyle interne au centre de l'échancrure intercondylienne; chez les hommes nous avons pris aussi la distance au plan tangent postérieur du condyle interne.

We have not used these measurements as we could not be certain of what they exactly correspond to.

measurements, if he wishes to complete his work within a reasonable number of years. We took 1, 2, 3, 4, 9 and 11. We regret to some extent having taken 4 only on a limited portion of our material. We attempted 5 and 6 and found them so indefinite and uncertain chiefly owing to wear that we concluded that they could not be treated as measurements of primary comparative value. 7 and 8 are suggested by Bumüller, but he admits that on the mesial condyle they are hard to determine; we found them extremely indefinite, so indefinite on the lateral as well as on the mesial condyle that we believe them too precarious to be of value in any exact research[1]. Of course our femora had been probably more than 200 years underground and were accordingly much worn. We cannot say what would be the rule on dissecting room material. Bumüller lays stress on what he terms the Condylar-articular Surface Index, *i.e.* 100 anterior arc/posterior arc. He (*loc. cit.* p. 82) states that the compound nature of the condylar-articular surface is easily recognisable in Man and in the Apes. We admit this but find the exact boundary line between the two and in particular Bumüller's limiting point not ascertainable in our femoral series. He gives for *twenty-five* femora only the mean Condylar-articular Surface Index as 56·6 for the lateral and 20·8 for the mesial condyle. He gives no measurements whatever for Apes, but remarks:

Die verschiedene Grösse der vorderen Partien macht sich auch in der Form der ganzen Kniegelenkfläche geltend. Dieselbe geht auf der lateralen Seite weiter nach oben, sie ist hier gleichsam hinaufgezogen. Die Begrenzung derselben ist daher nicht eine halbkreisförmige, sondern stellt eine gekrümmte, nach oben bald konvexe, bald gerade, bald konkave schiefe Linie dar, deren höchster Punkt auf der lateralen Seite liegt. Diese Form der Kniegelenkfläche und das Verhältniss der vorderen zur hinteren Partie am medialen Condylus ist für den Menschen charakteristisch, obwohl auch beim Affen in einzelnen Fällen ein ganz ähnliches Verhalten vorkommt. (*L.c.* p. 83.)

No statistics are provided of the relative frequency in the Ape of this asserted human characteristic, and the suggestion lacks that quantitative determination which, however laborious, alone can justify later investigators spending valuable time over a difficult and obscure measurement.

(*b*) With regard to the measurements 9 to 12, Bumüller states that 9 and 11 only are taken ("Wird nur am lateralen Condylus abgenommen," *l.c.* S. 141). We believe that the introduction of these measurements and the resulting "Band-radial Index" = 100 × vertical radius/horizontal radius, are due to Bumüller. He gives no reason for confining the measurements to the lateral side[2] but economy of labour and increased difficulty at least plead for such restriction. Bumüller has determined

[1] His description of the determination of these arcs is the following: "Die Länge der vorderen und hinteren Partie der medialen und lateralen Gelenkfläche wird mit dem Bandmaass bestimmt. Vordere Partie: je vom äusseren oberen Eck der Gelenkfläche bis zu dem einspringenden Winkel bei den Eindrücken der Menisci; ist medial öfters nicht exakt abzunehmen; hintere Partie: von genannten Winkel bis zum Ende der überknorpelten Fläche. Die vordere Partie wird am äusseren Rande, die hintere in der Mitte der Gelenkfläche gemessen." Bibl. 81, p. 141. It will be seen that the terminal of the anterior arc and the start of the posterior arc require the determination of two separate points. In the great bulk of cases these were not to be found on our femora with any adequate degree of accuracy.

[2] The sentence "Diese Bänder sind gespannt wenn der Fuss gestreckt ist, erschlaffen dagegen—besonders auf der lateralen Seite—bei gebeugtem Femur" (*l.c.* p. 81) contains, perhaps, his reason.

this index on five greater anthropoid femora, one gibbon's femur, and on four femora of monkeys. The following are his results[1]:

Chimpanzee ♂ R.	90	Gibbon (*Hylobates concolor*) L.	87
Orang ♂ R. ...	90	*Inuus sylvanus* R. ...	70
„ ♂ L. ...	85	*Cynocephalus gelada* R. ...	74·1
„ ♀ R. ...	83·3	*Lichanotus Indri* R.	81·8
„ ♀ L. ...	81·25	„ „ L.	81·8

His human sample consists of only *thirty* femora, and he states the mean as 112·3 and the range 100 to 128·6. He gives *Pithecanthropus erectus* the value 67 to 85. Here again our criticism repeats itself: Bumüller has made a suggestion, which may be a good one, but his quantitative evidence is wholly inadequate to justify *à priori* the adoption of this measurement generally. We did, however, add these measurements to our list, notwithstanding the very great uncertainty as to the exact epicondylar *point* from which the band-radii are to be measured[2]. The ligaments are attached to the border of an area often irregular, and with no well defined "centre"; it is especially hard to determine this centre in long interred bones. Again while we allow something to the mechanical stretching in the unflexed leg, we think it probable that at least a considerable portion of the tautness of the ligament in the unflexed state may be due to physiological causes. However the point appeared to be one in which the difference in posture between Man and the Apes might really lead to a differential criterion of the pithecoid and the human. Accordingly we did our best to obtain an independent determination of Bumüller's Band-radial Index. We paid no regard to his values of which the observers were not cognisant when taking their own measurements. The following table covers our own material.

TABLE XLV. *Table of Band-radial Indices.*

	Race	Band-radial Index			Race	Band-radial Index	
Lemuroids	*Tarsiidae* ...	70·9	(2)	Mean 85·47	*Dryopithecus rhenanus*	94·9 (1)	
	Galaginae ...	75·15	(6)				
	Chiromyrdae ...	77·45	(2)		Gorilla	97·64 (7)	Mean 93·85
	Lorisinae ...	81·9	(6)		Chimpanzee	97·25 (2)	
	Lemurinae ...	98·4	(18)		Orang-utan	82·7 (5)	
	Indrisinae ...	109·0	(8)		Gibbon	97·8 (2)	
Cebidae	*Hapalinae* ...	91·6	(16)	Mean 101·89	*Pithecanthropus erectus*	112·0?? (1)	
	Ateles	95·4	(4)				
	Pithecia	101·7	(2)		Neanderthal	98·4?? (1)	
	Mycetes	102·7	(2)		Spy	98·9?? (1)	
	Nyctipithecinae ...	104·1	(8)				
	Cebus	105·3	(6)		17th century Londoners	♂ 111·94 (337)	♀ 110·78 (227)
	Lagothrix ...	105·4	(2)		Australians	♂ 111·4 (2)	♀ 99·9 (2)
	Brachyurus ...	108·9	(2)		[Bumüller's Bavarians ...	♂ 112·3	♀ ?]
Simiadae	*Cynocephalus* ...	93·8	(8)	Mean 97·68			
	Cercopithecus ...	96·7	(8)				
	Macacus ...	97·7	(14)				
	Cercocebus ...	99·6	(4)				
	Semnopithecus ...	100·6	(10)				

[1] *Loc. cit.* p. 82 and Tabelle II, p. 112.

[2] The difficulty increases immensely when we have to deal with very small apes or lemuroids.

Now these results are of considerable interest and if slender are at least suggestive. We have:

Summary for Band-radial Index.

Lemuroids	85·47 (Type *Lorisinae*)
Cebidae	101·89 (Type *Pithecia*)
Simiadae	97·68 (Type *Macacus*)
Dryopithecus rhenanus	94·9
Ateles	95·4
Recent Gibbon	97·8
Simiinae (including Gibbon) ...	93·85 (Type Chimpanzee)
Neanderthal Type	98·4 ?
Recent Man (17th century Londoners)	111·36

Our values differ very widely from Bumüller's except in the case of Recent Man and the Orang where he has 112·3 and 84·9. Our values for the Gibbon are much in excess of his and more in keeping with the fossil *Dryopithecus* and with *Ateles*. 14 femora of *Macacus* give us 97·7 as against his 74·1 for a single femur. Further we find the bulk of the genera of *Cebidae* have an index in excess of 100 and *Semnopithecus* is over 100 among the *Simiadae*, while among the Lemuroids the *Indrisinae* occupy an exceptional, if not remarkable position. Thus we cannot accept the statement that for the apes the index is always under 100. Further for man himself our tables, p. 295, show that for a considerable percentage of cases we have found, measuring to the best of our ability, this index under 100. Still generally we confirm Bumüller's view that for the Anthropoids the Band-radial Index is less than 100 and that for Man the mean is markedly over 100. Our adequate sample of 337 males gives an index of 111·94, which is in absolute correspondence with Bumüller's 112·3 for 30 cases[1]. A suggestive but by no means demonstrated point is that the doubtful values for Primogenial Man of the Neanderthal Type are slightly less than 100, but bigger than the value for the Gorilla. If uprightness be markedly correlated with the Band-radial Index, then if we could possibly trust our values, Primogenial Man was intermediate in uprightness of gait between Modern Man and the Apes. It would be a useful, if difficult, task to ascertain the Band-radial Index in the long Paris series of Neolithic French. Of course this characteristic of gait is from the evolutionary standpoint a very important one, but the reader must be reminded that the data we have given for Primogenial Man are not only slender, but depend on very doubtful determinations. Further we must not overlook the fact that for the bulk of characters dealt with in this chapter, we have found that Primogenial Man is not a link between the Anthropoid Apes and either modern or primitive races of Man.

If we turn to *Pithecanthropus erectus* all we can say is that we determined as accurately as we were able the Band-radii on the illustrations of Dubois. We are and

[1] This exact concordance is of course fortuitous, the standard deviation of the index is from our results (p. 163) between 11 and 12 points. Hence the probable error of Bumüller's result is about 1·5, or all he could legitimately deduce from it was that the index probably lies between 109 and 115.

were unprejudiced as to whether the Trinil femur is pithecoid or human, and did not notice that the bulk of its characteristics were human and not pithecoid until the indices were worked out much later. We put no faith whatever in our value, because both band-radii were queried on determination. But our value is so human and Bumüller's is so pithecoid—indeed almost subpithecoid (except for an anomalous Orang of our own!)—that we feel quite safe in asserting that no criterion of the pithecoid character of the Trinil femur can be based as Bumüller supposes[1] on the Band-radial Index as found from the reproductions[2]. Our experience of more than 800 femora interred for only 200 years makes us gravely doubt whether it could be accurately determined on the Trinil femur itself. At any rate the fact that such widely divergent estimates are possible renders Professor Dubois' responsibility in postponing for more than twenty years an adequate scientific investigation of this femur very grave.

Another point is of such importance that it must be emphasised here. Out of 30 femora Bumüller found not a single apelike one, *i.e.* a femur with a vertical radius less than the horizontal. His range was 100 to 128. In the 561 London femora that permitted of any determination of the Band-radii we found 120 with indices less than 100 or 21·4 °/₀. On the face of it we found 21 °/₀ of human femora with an apelike character in this respect, but Bumüller, who in a random sample of 30 should on our scale have found 6, found none. Our range with a larger sample is from 81 to 144, *i.e.* 31 points below and 32 points above the mean. Bumüller's range is 12 points below and 16 above his mean, which at any rate suggests skewness of distribution, although the sample is too small for definite criticism. Now it is open to the reader to assert that our localisation of the "centre" of the band-radii was very poor; it was certainly doubtful in a considerable number of cases. Our only reply can be that we were as accurate as lay in our power both in determination of the centre and in the handling of special gauges constructed for fine work on metals, which we purchased for our work on the condyles. We are willing to give something of our 21 °/₀ to the vague character of the measurement, but far from the whole of it, and if this view be correct, it would follow that the human-range crosses the ape-range and that power of upright gait is not *solely* due to the tightening of the *ligamentum femoro-fibulare* mechanically, but has also a physiological origin. If this view be correct, the band-radial index is not for the *individual* an absolute test of the human or the pithecoid, but may on fair sized samples be a good criterion of the greater or less pithecoid character of a human race. From this aspect we would press for the attention of femoralogists to this index; the discovery of its mean values for primitive races, Australians, Fuegians, Moriori, Aino, etc., would be of very great interest, and the requisite material is available.

About the absolute values of the band-radii but little can be said because there is no material beyond our own. Their values in our 17th century Londoners are: horizontal band-radius ♂ 18·90, ♀ 16·81, vertical band-radius ♂ 20·82, ♀ 18·48, the

[1] "Der Bandradien Index (*i.e.* of *Pithecanthropus erectus*) ist *zweifellos* ein tierischer und *äffischer*.' *Loc. cit.* p. 131.

[2] See Fig. 2 of Plate XLVI, which is the source of the measurements.

maximum lengths of external condyle being ♂ 62·44 and ♀ 56·12. But the gorilla and chimpanzee have as large, if not larger, band-radii with very much smaller length of external condyle:

Gorilla: H. band-radius, 23·1, V. band-radius 22·5, Condyle 51·3.
Chimpanzee: „ „ 20·1, „ „ 19·6, „ 42·4.

The centre of the femoro-fibular ligament is thus relatively further removed from the anterior border of the condyle in the apes than in man, and the suggestion arises that an index based on this may differentiate pithecoid from human characters. We will term 100 × sum of band-radii/maximum length of external condyle, the Secondary Band-radial Index.

TABLE XLVI. *Table of Secondary Band-radial Indices.*

	Race	Secondary B. R. Index		
Lemuroidea	*Tarsiidae*	57·0	(2)	Mean 69·70
	Chiromyrdae	58·2	(2)	
	Galaginae	68·5	(6)	
	Indrisinae	70·1	(8)	
	Lemurinae	75·25	(18)	
	Lorisinae	89·15	(6)	
Cebidae	*Ateles*	71·6	(4)	Mean 82·18
	Nyctipithecinae	74·55	(8)	
	Hapalinae	75·15	(16)	
	Mycetes	80·0	(2)	
	Brachyurus	83·0	(2)	
	Lagothrix	87·8	(2)	
	Pithecia	90·8	(2)	
	Cebus	94·5	(6)	
Simiadae	*Cynocephalus*	70·7	(8)	Mean 77·76
	Cercopithecus	72·3	(8)	
	Macacus	75·5	(14)	
	Semnopithecus	79·9	(10)	
	Cercocebus	90·4	(4)	

Race	Secondary B. R. Index		
Dryopithecus rhenanus ...	86·1	(1)	
Chimpanzee	91·36	(2)	Mean 86·54
Gorilla	89·01	(7)	
Orang-utan	84·13	(5)	
Gibbon	81·67	(2)	
Pithecanthropus erectus ...	68·17??	(1)	
Primogenial Man (mean Neanderthal Spy) ...	71·03?	(2)	
17th century London Males	63·61	(337)	
17th century London Females	62·88	(227)	
Australians, Males	51·3	(2)	
Australians, Females ...	55·0	(2)	

Summary.

Lemuroidea	69·70	(Type *Indrisinae*)
Cebidae	82·18	(Type *Brachyurus*)
Simiadae	77·76	(Type *Macacus*)
Dryopithecus rhenanus	86·1	
Simiinae (including Gibbon) ...	86·54	(Type Orang)
Primogenial Man (Neanderthal Type)	71·03?	
Recent Man (17th century Londoners)	63·25	

The noteworthy point is that the *Cebidae* have advanced further than the *Simiadae*, indeed in the uppermost grade to the anthropoid value, while from Neanderthal Man to Recent Man there has been a reversion to a value scarcely paralleled by the Lemuroids, *Tarsius* and the Aye-Aye excepted.

Our slender material indicates a wider range of difference than even in the case of the primary band-radial index but the same order—Anthropoid Apes, Primogenial Man of the Neanderthal Type, Recent Man—is maintained in the lower portion of the table. The exceedingly doubtful value for the Trinil femur places that femur between Primogenial and Recent Man, as far as *mean* values are concerned, but still within the human range. Its value is far removed from that of the Gibbon. The situation on the condyle of the attachment of the femoro-fibular ligament would we should imagine be closely associated with the supposed arboreal life of *Pithecanthropus erectus*. Could we fully trust the above value of the secondary index for the Trinil femur—which is not possible—it would be an additional strong argument, were such needed, against this femur being that of a giant Gibbon.

The secondary band-radial index seems as likely as the primary to be of marked service in grading the degree of pithecoid character in man. We think both might well be studied in conjunction. In particular the low values obtained for the orang need confirmation, and this might well form part of an extended study of the femur of the anthropoids.

(iv) *Absolute Lengths of the Condyles.*

We have already stated how our own condylar lengths are measured (p. 18), but it may be as well here to consider what other writers have said on the subject. Bümüller grasps fully the importance of the two measurements of the length of the condyles, namely the natural or maximum length and the projected or oblique length. His description of his manner of measurement is, however, not very precise. He writes[1]:

Natürliche Länge beider Condylen mit dem Schiebezirkel von der höchsten vorderen (Kniegelenkfläche) bis zur höchsten hinteren Erhebung (Maximum der Krümmung) ungefähr in der Höhe des Epicondylus.

"Erhebung" from what? Does it refer to central plane of articular surface of condyle, or to the border of it, or to one or other of these as the case may be? Again what is the "Maximum der Krümmung"? Is it the maximum curvature of the middle section of the condyle, or of its border or of the plane perpendicular to these? In our taking of the "natural" or maximum length we proceeded as follows: The base bar of the calipers was placed over the epicondyle as nearly parallel to the median plane of the condyle as could be estimated and roughly parallel to the standard horizontal plane, the fixed bar and the sliding bar were then brought into contact with the anterior and posterior articular surfaces the base bar being adjusted so as to take the maximum measurement whether it occurred at the border of the articular surface or at points nearer to the median plane. The measurement is roughly at the level of the epicondyle. The main point is that we took not a skew measurement, *i.e.* from, say, a point on border to a point on median plane, but the maximum diameter of a *projection* of the condyle on the median plane of the condyle, whereas the oblique length was the maximum diameter of a projection of the condyle on the standard sagittal plane[2]. If we take the highest and lowest points of the

[1] Bibl. 81, S. 141 (22).

[2] That is the plane perpendicular to the standard horizontal and vertical planes through the intercondylar point.

condylar articular surface relative to the standard vertical plane we may get a skew "natural" length, *i.e.* one not parallel to the median plane of the condyle and this does not appear justified. Martin[1] under "Dicke des Condylus" measures the oblique length, so does Lehmann-Nitsche[2], and both confine their attention to the *external* condyle. Klaatsch is very brief in his statement:

Die Länge der Kondylen. So bezeichnet man wohl am besten den grössten Durchmesser der Kondylen in der Richtung von vorn nach hintern (Bumüller)[3].

Klaatsch does not appear to have noticed that Martin and Lehmann-Nitsche are measuring the oblique length, namely Bumüller's "Projectionslänge des *condylus externus*" or the greatest height of the condyles above the base-board of the osteometer when the bone is in the standard position. This as Bumüller with some truth observes[4] may be the projection length of the *condylus internus* in the case of many apes. Hultkrantz[5] uses the term "Dicke des *condylus externus*," and we believe has measured the oblique length. Klaatsch uses both Bumüller's and Hultkrantz's results and adds others of his own. We are inclined to believe he has really measured the oblique lengths, but his wording just quoted suggests the maximum length.

The question which lengths have been measured is of great importance, because the lengths' difference, upon which great stress has been laid as a criterion of pithecoid character, is very diverse when taken on the natural and when taken on the oblique lengths. As a matter of fact when taken on the natural lengths we are measuring a true *size* difference in the two condyles, but when taken on the oblique lengths we are largely measuring a *positional* difference of the two condyles. Thus Bumüller starts by saying that the external or lateral condyle in man is "kräftig entwickelt," but the internal or mesial condyle is "weniger kräftig entwickelt," while the reverse holds for the anthropoids and most apes. He says that this difference of size need not be measured, but is sensible if the bone be placed on a horizontal plane[6]. It is perfectly true that the mesial condyle in the standard position of the bone is as a rule outtopped by the lateral condyle, and this is largely a result of position and not of absolute size, the mesial condyle slopes far more to the standard sagittal plane, than the lateral and this Bumüller appears to admit at the bottom of the page just cited:

Legen wir das femur mit seiner dorsalen Seite horizontal auf, so steht die äussere Fläche des *Cond. lat.* ziemlich senkrecht auf der Messplatte, während die äussere Fläche des *Cond. lat.* ziemlich schief nach aussen verlängt.

There are in fact in man such small mean differences in the natural lengths of the two condyles that they could not be appreciated by the unaided eye, as we shall shortly indicate. The more "kräftig entwickelt" appearance of the lateral condyle to which Bumüller refers can only be a result of their difference of position, or to a difference of size measured say by their *breadths* not their lengths. But such breadths

[1] Bibl. 63, S. 202.
[2] Bibl. 69, S. 286.
[3] Bibl. 87, S. 613.
[4] Bibl. 81, S. 140 (17).
[5] Bibl. 85, S. 173 (seems to follow Martin).
[6] Bibl. 81, S. 80.

are not under discussion[1]. We think it desirable to give our full data on this point in order to counteract the very current view that the lateral condyle is much larger than the mesial.

Difference of Natural Condylar Lengths (Lateral – Mesial).

−8·5 to −7·5	−7·5 to −6·5	−6·5 to −5·5	−5·5 to −4·5	−4·5 to −3·5	−3·5 to −2·5	−2·5 to −1·5	−1·5 to −0·5	−0·5 to 0·5	0·5 to 1·5	1·5 to 2·5	2·5 to 3·5	3·5 to 4·5	4·5 to 5·5	5·5 to 6·5	6·5 to 7·5	7·5 to 8·5	Total			
—	—	1	2	3·5	15	13·5	23·5	39·5	26·5	21·5	12	15	4	2	—	1	180	17th cent. Londoners	♂	R.
—	—	—	5	7	14·5	23·5	28·5	32·5	28	22	12	6·5	1·5	1	—	—	182	,,	,,	♂ L.
—	·5	·5	1	1·5	7·5	11·5	18·5	22·5	18	25	10	5·5	4	2	—	—	128	,,	,,	♀ R.
1	—	1	2	3	7	13	23	20·5	26·5	16	10	8·5	4·5	—	—	—	136	,,	,,	♀ L.
—	—	—	—	—	1	3	3	2	10	4	4	—	—	—	—	—	27	Klaatsch's "Europeans"		

Our four series give for the means:

♂ R. + ·444 ± ·113 ♂ L. − ·135 ± ·111

♀ R. + ·551 ± ·135 ♀ L. + ·287 ± ·136.

It will be seen that actually our male left femora give an insignificant *negative* value while the female left series is scarcely significant. The right series for both sexes give significant but very small values about half a millimetre. Klaatsch's small series gives + ·667 ± ·216[2], a value considering its probable error quite in keeping with ours. It does not seem reasonable to suppose that this ½ mm. in natural length would be appreciated by the unaided eye. It is to be noted that the modal value for both male series is *zero* difference. The female series being short show some irregularity, but the true modes cannot be far from zero. Now out of our 626 femora 286 gave a *negative* difference or 46 °/₀. In Klaatsch's short series 30 °/₀ had a larger mesial condyle and in Bumüller's series in 30 °/₀ of cases there was equality or excess of the mesial condylar length. In view of this we conclude as against Klaatsch that it is not possible on the basis of the − 1·8 difference in condyle lengths to assert that the Trinil femur is pithecoid in character. A difference greater than − 1·5 occurs in more than 21 °/₀ of our femora and therefore cannot be considered as demonstrating pithecoid character in an isolated individual. Negative racial *means* would, however,

[1] The only data we know on this point are the few provided by Zanolli, who gives the index 100 × *Diam. trasv. cond. interno/Diam. trasv. cond. laterale* = presumably the ratio of *breadth* of internal to that of external condyle as 93·8 for 20 ♂ and 96·0 for 23 ♀ Bolognese, and possibly Klaatsch's somewhat mysterious "Condylen lat. Diam. longitudinalis" and "Condylen med. Diam. longitudinalis" of the Aurignac (R. 31, L. ?, R. 34, L. 35) and Neanderthal (R. 37, R. 42) femora respectively. (Bibl. 103bis, S. 329, Tabelle 8.)

[2] It is possible that this represents the difference of *oblique* lengths, in which case the agreement would not be so close. Bumüller gives for 27 ♂s, presumably Bavarians, a difference of 2 mm. in the natural lengths and states that in four there was equality and in four excess of mesial condyle. He further gives 3·25 mm. as the difference in the projected or oblique condyle lengths of 12 femora, the range being from + 1 to + 6. Both these series are too short to be of any real value. We find for 73 ♂s a difference of + 4·30 and for 62 ♀s one of + 3·55, which indicate that the difference of the oblique lengths is very much greater than that of the natural lengths.

signify *pro tanto* in human data an approach to pithecoid character, although no stress can be laid on a negative value in an isolated individual.

The table on p. 404 gives the absolute values we have been able to collect and they are summarised below.

Summary for Lengths of Condyles.

	Maximum Length		Oblique Length		Difference of Lengths	
	Lateral	Mesial	Lateral	Mesial	Maximum	Oblique
Lemuroids	13·28	12·73	12·21	11·85	+ ·38	+ ·36
Cebidae	14·74	14·91	14·08	13·86	− ·17	+ ·19
Simiadae	24·96	25·36	24·14	23·65	− ·20	+ ·49
Dryopithecus rhenanus ...	31·0	30·0	29·2	28·6	+ 1·00	+ ·60
Gibbon	18·1	19·4	17·67	17·73	− 1·3	− ·17
Ateles	24·1	25·25	23·6	23·5	− 1·15	− ·10
Greater Anthropoids	42·67	51·80	41·65	46·18	− 9·13	− 4·53
Neanderthal Type	72·5	66·7	71·1	66·7	+ 5·8	+ 4·4
17th century Londoners ♂ + ♀	59·28	58·81	58·46	54·20	+ ·28	+ 3·92

It is clear from the longer table that for Lemuroids and lesser apes the differences of the condyle lengths, whether maximum or oblique, are small and by no means of the same sign in the same family, still less so within the genus or species. On the whole the difference of oblique lengths is generally positive, but exception occurs in all the *Simiinae*, where not only the difference of the oblique lengths but of the maximum lengths also is negative and considerable. *Dryopithecus rhenanus* is an exception in our measurement, but not in Klaatsch's, and is thus out of the accordance it usually has with the Gibbon and *Ateles*. The sudden appearance of large negative values in the Greater Anthropoids seems to be beyond question and is somewhat startling when compared with large positive values in the Neanderthal Type. The large positive difference appears to be retained in Recent Man for the oblique lengths, but falls to a very small quantity in the case of the maximum lengths. Unfortunately we have no values for the Cromagnon Type or the Grimaldi Type to throw light on the transition from Neanderthal Type to Recent Man. It is clear from the longer table and what goes before that although individual genera may have excess of the maximum length of the lateral condyle, yet in a broad way Bumüller's statement is correct, if it is merely a statement of averages. On the average the lesser apes and anthropoids have a longer mesial than lateral condyle and this position is reversed in both Primogenial and Recent Man. Recent Man, however, for maximum length of condyles appears to have regressed on Primogenial Man and to stand between him and the apes. This is a position we so often find occurring, and should cause those to pause, who sum up Neanderthal Man as being more "gorilloid" than Recent Man. He is, but only in a very limited number of characters.

Probably it will already have occurred to the reader that while the *sign* of this difference is interesting its absolute value is of small weight, because femora of larger build will essentially have a larger condyle difference. The difference therefore needs

TABLE XLVII. *Table of Maximum and Oblique Condylar Lengths.*

	Race*	Maximum Length		Oblique Length		Δ_1	Δ_2	Authority
		a Lateral Condyle	*b* Mesial Condyle	*c* Lateral Condyle	*d* Mesial Condyle	*a* − *b*	*c* − *d*	
Lemuroids	*Tarsiidae* (2)	8·25	8·3	7·55	7·7	− ·05	− ·15	Pearson and Bell
	Lorisinae (6)	8·3	9·5	7·85	8·5	− 1·20	− ·65	,,
	Galaginae (6)	9·2	9·0	8·2	7·75	+ ·20	+ ·45	,,
	Chiromyrdae (2)	16·5	15·3	15·05	14·75	+ 1·20	+ ·30	,,
	Lemurinae (18)	18·2	17·0	16·6	15·7	+ 1·20	+ ·90	,,
	Indrisinae (8)	19·2	17·25	18·0	16·7	+ ·95	+ 1·30	,,
		Mean 13·28	Mean 12·73	Mean 12·21	Mean 11·85	Mean + ·38	Mean + ·36	
Cebidae	*Hapalinae* (16)	8·65	8·2	7·9	7·6	+ ·45	+ ·30	Pearson and Bell
	Nyctipithecinae (8)	11·0	10·9	10·3	10 1	+ ·10	+ ·20	,,
	Pithecia (2)	13·1	12·9	12·7	12·2	+ ·20	+ ·50	,,
	Lagothrix (2)	13·1	13·45	12·55	12 45	− ·35	+ ·10	,,
	Cebus (6)	13·6	14·1	13·0	13·05	− ·50	− ·05	,,
	Brachyurus (2)	15·6	15·05	14·8	14·35	+ ·55	+ ·45	,,
	Mycetes (2)	18·75	19·4	17·75	17·65	− ·65	+ ·10	,,
	Ateles (4)	24·1	25·25	23·6	23·5	− 1·15	− ·10	,,
		Mean 14·74	Mean 14·91	Mean 14·08	Mean 13·86	Mean − ·17	Mean + ·19	
Simiadae	*Cercopithecus* (8)	19·5	19·7	18·9	18·7	− ·20	+ ·20	Pearson and Bell
	Macacus (14)	23·7	24·7	23·1	22·9	− 1·00	+ ·20	,,
	Semnopithecus (10)	24·9	24·1	23·4	22·4	+ ·80	+ 1·00	,,
	Cercocebus (4)	26·15	26·4	25·0	24·65	− ·25	+ ·35	,,
	Cynocephalus (8)	30·55	31·9	30·3	29·6	− ·35	+ ·70	,,
		Mean 24·96	Mean 25·36	Mean 24·14	Mean 23 65	Mean − ·20	Mean + ·49	
	Dryopithecus rhenanus	31·0 (1)	30·0 (1)	29·2 (1)	28·6 (1)	+ 1·00	+ ·60	From cast
	The following results from other authors more or less confirm our values above.							
	Lemur catta (1)	17·0	16·0	—	—	+ 1·0	—	Klaatsch*
	Alonata geniculus (2)	17·7	19·2	—	—	− 1·5	—	Hrdlička†
	Cebus capuchinus (1)	15·0	14·5	—	—	+ 0·5	—	Klaatsch
	Cebus hypoleucus (1)	16·5	18·0	—	—	− 1·5	—	Hrdlička
	Mycetes (1)	26·0	29·0	—	—	− 3·0	—	Klaatsch
	Ateles (1)	19 0	20·0	—	—	− 1·0	—	,,
	Cynocephalus anubis (1)	37·0	39·1	—	—	− 2·0	—	,,
	Cynocephalus porcarius (1)	31·0	33·1	—	—	− 2·0	—	Hrdlička
	Dryopithecus rhenanus (1)	29·0	30·0	—	—	− 1·00 (!)	—	Klaatsch

* It is possible that all Klaatsch's values in this table are for the *oblique* condylar lengths, although he speaks of the "maximum diameter." His results for the Neanderthal and Spy femora would then agree better with ours on the casts. But Klaatsch scorned biometric methods and never read to a fraction of a millimetre, so that one can never be very certain of his measurements.

† We have inserted Hrdlička's measurements in this table of "Maximum Antero-posterior Diameters of Inner and Outer Condyles," but as in the case of Klaatsch cannot be sure it is not the projective or oblique length that he is measuring. This doubt is emphasised by the fact that he also gives a "Maximum Antero-posterior Diameter of the Lower Extremity of the Femur." This in the *Tetraprothomo* is of the same size as the "Max. Diameter Ant. Post. of the inner Condyle"; such is also the case in the femora of a Jaguar and an Ocelot, while in that of a Puma it is even greater. On the other hand in all the apes it is less. Hrdlička gives the like measurements on the femur of a white man 59·5, 62·0 with a difference − 2·5—a striking instance of the danger of taking a single instance to provide a type! We have not thought it needful to include this isolated human case in the table. *Tetraprothomo* refers to the fossil catlike femur found on Monte Hermosa whose owner, Ameghino suggests, was a direct ancestor of man. For Hrdlička, see "Skeletal Remains of Early Man," *Smithsonian Institute, Bulletin of Bureau of American Eth-*

	Hylobates lar (1)	18·3	19·9	17·8	18·0	− 1·6	− ·20	Pearson and Bell
	,, *mulleri* (2)	18·0	19·15	17·45	17·6	− 1·15	− ·15	,,
	,, *syndactylis* (1)	32·0	36·0	—	—	− 4·0	—	Klaatsch
	,, ? (1)	20·5	22·0	—	—	− 1·5	—	Hrdlička†
Simiinae	Orang-utan (5)	33·4	41·2	33·0	35·8	− 7·8	− 2·8	Pearson and Bell
	,, (1)	45·0	57·0	—	—	− 12·0	—	Hrdlička
	,, (1)	—	—	—	—	− 12·0	—	Bumüller
	Chimpanzee (2)	43·4	51·5	41·45	45·45	− 8·1	− 4·0	Pearson and Bell
	,, (1)	41·0	52·0	—	—	− 15·0	—	Klaatsch
	,, (1)	43·0	48·0	—	—	− 5·0	—	Hrdlička
	Gorilla (7)	51·2	62·7	50·5	57·3	− 11·5	− 6·8	Pearson and Bell
	,, (3)	43·7	56·7	—	—	− 13·0	—	Klaatsch
	,, (1)	42·0	51·0	—	—	− 9·0	—	Hrdlička
	Pithecanthropus erectus	62·2	64·0	62·0?	61·0?	− 1·8	+ 1·0?	Photographs
	Tetraprothomo (Ameghino) (1) ...	34·0	38·0	—	—	− 4·0	—	Hrdlička†
Primogenial Man	Neanderthal Type (6)	72·5	66·7	71·1	66·7	+ 5·8	+ 4·4	Various
	Homo mousteriensis (Hauseri) (1)	70·4?	60·0?	68·0?	—	+ 10·4?	—	From cast
	La Chapelle-aux-Saints (1) ...	[70·7]‡	64·0?	—	—	+ 6·7?	—	Photographs
	Neanderthal L.	75·2	69·5	74·2	—	+ 5·7	—	From cast
	,, ,, ...	71·0	66·0	—	—	+ 5·0	—	Klaatsch
	,, R.	70·0	67·0	—	—	+ 3·0	—	,,
	Spy I R.	73·7	69·1	72·2§	—	+ 4·6	—	From cast
	,, ,, ...	72·0	67·0	—	—	+ 5·0	—	Klaatsch
	Galley Hill	> 64·0	—	> 60·9‖	—	—	—	From cast
Recent Man	Badenser (27)	61·00	60·33	—	—	+ ·67	—	Klaatsch
	17th century Londoners ...	♂ 62·44 (389)	62·06 (418)	61·45 (416)	56·12 (73)	+ ·15 (362)	+ 4·30 (73)	Pearson and Bell
	,, ,, ...	♀ 56·12 (283)	55·56 (315)	55·48 (299)	52·29 (62)	+ ·42 (264)	+ 3·55 (62)	,,
	Bavarian Males	—	—	—	—	+ 2·00 (12)	+ 3·25 (27)	Bumüller
	Fuegians (10)	—	—	62·4	—	—	—	Hultkrantz
	Australians (4)	♂♂ 65·95	66·3	65·35	60·85	− 0·35	+ 4·50	Pearson and Bell
		♀ 57·85	57·7	57·15	54·25	+ 0·15	+ 2·90	
	Gilbert Islander (1)	65·0	63·0	—	—	+ 2·0	—	Klaatsch
	Malay (1)	59·0	58·0	—	—	+ 1·0	—	,,
	Javanese (1)	58·0	55·0	—	—	+ 3·0	—	,,
	Negrito (1)	53·0	53·0	—	—	0·0	—	,,
	Negroes ♂	61·9	59·3	61·5	—	+ 2·6	—	Various
	,, ♀	56·2	53·1	55·5	—	+ 3·1	—	,,

nology, 1912, pp. 380—3, and for Ameghino, Bibl. 100ter. In all the genera dealt with by Hrdlička including man he finds the antero-posterior maximum length of the mesial condyle *greater* than that of the lateral condyle (*l c.* p. 383). He does not appear to have noticed that European femoralogists had asserted previously that this relation of the condyles was actually a criterion for distinguishing the pithecoid from the human.

‡ Reconstructed value and therefore doubtful.

§ Fraipont and Lohest give the "antero-posterior diameter of the condyle" as 55 in Spy No. 1 (Bibl. 42bis, S. 651—6). This is wholly out of keeping with the cast or with Klaatsch's statement of values.

‖ Newton (Bibl. 69bis, p. 508) says "length of condyles" is 62. It is not clear what is meant by "length of condyles" and the cast suggests that the bone is too defective to measure any condylar length. But then this author holds it sufficiently definite to state of the Galley Hill femur that "the long axes of these two portions [shaft and neck] seem to be at the usual angle with each other"! (p. 509).

to be divided by a quantity measuring the size of the bone and we not unnaturally take the maximum length of the mesial condyle itself. But this leads us directly to the consideration of whether the Condylar Lengths Index is in excess or defect of 100. A study of this index, however, will be found not to upset the very broad generalisations we have drawn from the crude differences.

(v) *Condylar Lengths Indices.*

This important index we take to be 100 × natural length of lateral condyle/natural length of mesial condyle. A similar index may be formed of the projective or oblique lengths and with several authors we cannot by any means be certain which lengths they have measured. The differences of the indices are not so considerable as might be supposed as both lengths are reduced. Still they are not reduced proportionately, and this while possibly not affecting the main features will certainly modify the minor details of the generic or racial order. At present the matter is not of such great importance as we have only slender data for the races of Recent Man, but it may be hoped that femoralogists in supplying this immediate need will take if possible both indices, or, if one only, will base their observations on the natural condylar lengths.

The following tables contain all the data we have thus far been able to collect.

The first table gives our results for the Condylar Lengths Index (*Oblique* Lengths) of the Primates.

TABLE XLVIII. *Condylar Lengths Index* (Oblique or Projected Lengths).

Lemuroidea	*Lorisinae* (6)	92·34	Mean 95·19	Mean 101·96
	Tarsiidae (2)	98·05		
	Chiromyrdae (2)	102·03		
	Lemurinae (18)	105·73		
	Galaginae (6)	105·81		
	Indrisinae (8)	107·78		
Cebidae	*Cebus* (6)	99·62	Mean 101·82	
	Ateles (4)	100·43		
	Mycetes (2)	100·57		
	Lagothrix (2)	100·80		
	Nyctipithecinae (8)	101·98		
	Brachyurus (2)	103·14		
	Hapalinae (16)	103·95		
	Pithecia (2)	104·10		
Simiadae	*Macacus* (14)	100·87	Mean 102·04	
	Cercopithecus (8)	101·07		
	Cercocebus (4)	101·42		
	Cynocephalus (8)	102·36		
	Semnopithecus (10)	104·46		
Simiinae — Hylobates	*Dryopithecus rhenanus* (1)	102·10		
	Recent Gibbon (2)	99·15		
	[*Ateles* (4) (for comparison)	100·43]		
Simiinae — Greater Anthropoids	Gorilla ♂ 87·31 (4), ♀ 89·42 (3)		Mean 90·53	
	Gorilla ♂ + ♀ 88·21 (7)			
	Chimpanzee (2)	91·20		
	Orang-utan (5)	92·18		
	Pithecanthropus erectus (1)	101·6 ?		
Hominidae	Primogenial Man, Neanderthal Type	106·6		
	Recent Man (17th century Londoners) ♂	107·66 (73)		
	Recent Man (17th century Londoners) ♀	106·79 (62)		
	Recent Man (17th century Londoners) ♂ + ♀	107·26 (135)		
	Australians ♂ 107·4 (2) ♀ 105·3 (2)			

TABLE XLIX. *Condylar Lengths Index* (Natural or Maximum Lengths).

Group		Value of Index		Source of Material
Lemuroids	*Lorisinae* (6)	86·9	Mean 102·65	Pearson and Bell
	Tarsiidae (2)... ...	99·4		,,
	Galaginae (6) ...	103·5		,,
	Lemurinae (18) ...	106·8		,,
	Chiromyrdae (2) ...	107·9		,,
	Indrisinae (6) ...	111·4		,,
Cebidae	*Ateles* (4)	95·5	Mean 99·77	Pearson and Bell
	Cebus (6)	96 6		,,
	Mycetes (2)	96·65		,,
	Lagothrix (2) ...	97·4		,,
	Nyctipithecinae (8) ...	101·1		,,
	Pithecia (2)	101·55		,,
	Brachyurus (2) ...	103·65		,,
	Hapalinae (16) ...	105·7		,,
Simiadae	*Macacus* (14)... ...	96·0	Mean 98·87	Pearson and Bell
	Cynocephalus (8) ...	97·2		,,
	Cercocebus (4) ...	99·05		,,
	Cercopithecus (8) ...	99·2		,,
	Semnopithecus (10) ...	102·9		,,
	Lemuroidea (4)	111·16		Collected from various authorities for comparison with above
	"New World Monkeys" (5)	91·89	95·38	
	Platyrrhini (5)	98·88		
	Cercopithecidae (10) ...	98·21		
	Dryopithecus rhenanus (1)	105·3		Cast
	,, ,,	96·7		Klaatsch
	Pithecanthropus erectus ...	97·2?		From photographs

Group		Value of Index		Source of Material
Simiinae	Orang-utan (5)	81·2	Mean P. & B. 82·40 Rest 82·12	Pearson and Bell
	,, (6)	80·65		Various authors
	Gorilla (7)	81·8		Pearson and Bell
	,, (8)	83·53		Various authors
	Chimpanzee (2)	84·2		Pearson and Bell
	,, (4)	82·18		Various authors
	Gibbon (2)	94·1		Pearson and Bell
	,, (5)	91·34		Various authors
Mammals	*Ursus americanus* (1) ...	79·55	Mean 95·59	Hrdlička
	Tetraprothomo (Ameghino) (1)	89·47		,,
	Hyena striata	94·16		,,
	Modern N. American *Canidae*	95·32		,,
	Ancient N. American *Canidae*	95·32		,,
	Modern S. American *Felidae*	99·30		,,
	Ancient N. American *Felidae*	100·00		,,
Recent Man	Australians	♂ 99·5 (2) ♀ 100·2 (2)		Pearson and Bell
	Negrito (1)	100·0		Klaatsch
	17th century Londoners ...	♂ 100·34 (356) ♀ 100·80 (259)		Pearson and Bell
	Badenser (27)	101·11		Klaatsch
	Modern Bolognese	♂ 101·01 (20) ♀ 101·42 (23)		Zanolli
	Malay (1)	101·7		Klaatsch
	Bavarians (27)	103·0 (?♂)		Bumüller
	Gilbert Islander (1)	103·2		Klaatsch
	Javanese (1)	105·5		,,
Primogenial Man	Spy (1)	106·7	Mean 110·7	From cast
	Neanderthal (1)	108·2		,,
	La Chapelle-aux-Saints (1)	110·5?		From photographs
	Homo mousteriensis (*Hauseri*)	117·3!?		From cast

We summarise as below:

Condylar Lengths Indices.

	Maximum Lengths	Oblique Lengths
Lemuroids	102·65	101·96
Cebidae	99·77	101·82
Simiadae	98·87	102·04
Dryopithecus rhenanus ...	105·3	102·10
Gibbon	94·1	99·15
Ateles	95·5	100·43
Greater Anthropoids	81·9	90·53
Neanderthal Type	110·7	106·6
Recent Man (17th century-Londoners) ...	100·53	107·3

Now this summary is very suggestive, the ratio of maximum condylar lengths falls continuously from Lemuroids to Greater Anthropoids. There is hardly any change in the oblique lengths from Lemuroids to lesser apes and even to the gibbon, but a sudden fall occurs at the Greater Anthropoids. This is followed by a correspondingly great rise in Primogenial Man, a rise maintained for the oblique lengths, but not for the maximum lengths, in the case of Recent Man. Neanderthal Man is much closer to Recent Man than to any Recent Anthropoids, and he appears to be the very reverse of "gorilloid" or even "orangoid" in the ratio of his condylar lengths. The fossil gibbon, however, suggests that the tendency to exaggerate the mesial at the expense of the lateral condyle is relatively recent in the *Simiinae* even in the gibbon, and that if we could find fossil femora of the Greater Anthropoids, their condylar indices would be more like those of the Eppelsheimer femur and so more human. In other words that as far as this character of the distal epiphysis goes, man is more primitive than the modern *Simiinae, i.e.* he approximates more to the lesser apes. Indeed an examination of the complete tables indicates that in none of the great primate families have genera ever been wanting with their condylar indices far removed from those of Recent Man—the reader has only to look at both indices for *Semnopithecus*, *Hapalinae* and the true Lemurs. What is wanting is an explanation of why Man is like these particular genera of the lesser apes rather than like recent anthropoids. It can hardly be uprightness of gait which for this character separates man from the gorilla in the same way as *Semnopithecus* is separated from *Macacus*, the *Hapalinae* from *Ateles* or *Cebus* and the *Indrisinae* from the *Lorisinae*. Some feature of muscular development, some characteristic use of the knee-joint in posture or progression, ought to associate the *Indrisinae*, *Hapalinae*, *Semnopithecus* and Man, and differentiate them from the *Lorisinae*, *Cebus*, *Macacus* and the *Simiinae*. In what respect do these groups fill supplementary places in nature?

We have included in the first of the above tables the few individual femora for which Klaatsch provides data and this for two purposes, (i) to indicate the absolute idleness of publishing measurements on single individuals. We are quite certain that when a complete racial table for the Condylar Lengths Index in Recent Man has

been obtained racial differentiation will be found between the Bavarians and Gilbert Islanders and between the Malays and the Italians; (ii) to indicate on the basis of the very slender material yet available that the big genera in our table are as far as we are able to judge differentiated in their *means*. The table in itself is extraordinarily suggestive, the order of increasing value of index being Anthropoids, Monkeys, Recent Man, Primogenial Man of the Neanderthal Type. The monkeys in this characteristic—equality of condyles—are nearer to man than the anthropoids or Primogenial Man. Whereas in Recent Man and the Monkeys, there is an approach to equality, the anthropoids show marked excess of the mesial condyle and the Neanderthal marked defect of the mesial condyle relative to the lateral condyle. In other words Primogenial Man is in this—as in a good many other respects—farther removed than Recent Man from the Lesser Apes. It is again as if, in the Neanderthal Type, a favourable variation had been overdone and Recent Man had had to return to a lower value closer to that of the Lesser Apes. One would certainly in the state of our present knowledge like to think of the Neanderthal Type as a gorilloid version of man, which had failed from the evolutionary standpoint. But there are so many features of the Neanderthal Type femur in which it differs more than Recent Man from the larger Anthropoids, that one is compelled to believe that the description of the Neanderthal Type as a gorilloid type of man is due principally to its general massiveness in appearance, supported by a few characters like the absence of a pilaster, the high Index of Robusticity and the absolute size of Head, but does not depend on a more minute quantitative study of the relative proportions of the parts. In a considerable number of relative characters it will be found that the average femur of the *Simiadae* is closer than that of the orang to the femur of Recent Man, and fascinating as is Klaatsch's suggestion[1]—based principally, we fear, on visual appearance—of an orangoid origin for Recent Man and a gorilloid origin for Primogenial Man of the Neanderthal Type, we do not think it will stand a more minute investigation of femoral characters. The fundamental point in the discussion of the present character is the drawing together in the centre of Recent Man and the Lesser Apes, and the appearance on *opposite* flanks of Primogenial Man and the Recent Anthropoids. Those flanks were probably relative failures because they were opposite extremes. Do we suggest then that man has descended from a Lesser Ape form without passing through an anthropoid stage? On the contrary we hold that the protsimio-human was a troglodyte in form of femur, but that for this character he was, like *Dryopithecus rhenanus*, much more human than recent anthropoids, and this because he was approaching more closely to the branch point of the *Simiadae*. It is confirmatory of this interpretation that Recent Man so frequently *appears* to have reverted to the Lesser Apes. It only signifies that in some characters he is more primitive than Recent Anthropoids, by which we mean more like the common ancestor—the troglodyte[2] who would naturally be nearer than they are to the branch point of the *Simiadae*. Of

[1] Bibl. 102ter, S. 91—99 and Bibl. 102bis, S. 513—577.

[2] The sense in which we use troglodyte for a *primitive* Chimpanzee-like femur will be more fully elucidated in the following chapter.

course some stress is here laid on the position taken by *Dryopithecus rhenanus* which indicates a "converging value" for the Condylar Lengths Index of the *Simiinae*. We are, however, depressed by the fact that Bumüller gives 96·7 instead of our 105·3[1].

The reader will notice that in our table we have included certain interesting results for the mammals due to Hrdlička. These values seem to justify that writer's opinion that the Monte Hermosa femur, which has been entitled *Tetraprothomo* by Ameghino and is looked upon by him as something of the nature of a protsimiohuman, is probably the bone of one of the fossil American *Felidae*. The mean of Hrdlička's *Canidae* and *Felidae* group is 95·59, which is somewhat above the *Tetraprothomo* femur (89·5). That value, however, is flanked by Hrdlička's single specimen of the *Ursidae* (79·6) and these values are all much below that of the average Lemuroid and those of the Lesser Apes. On the other hand while not corresponding to any of the recent Greater Anthropoids, it has an approximation to a gibbon-like value. Unfortunately this fossil femur is not in the least like a gibbon's, and if it were we have every reason to believe that fossil gibbons had a very

[1] We indicate elsewhere that the cast of the *Dryopithecus rhenanus* is not wholly reliable for exact measurements. Beyond Klaatsch's measurements of the condylar lengths of the Eppelsheimer femur and some few values provided by Bumüller we have not succeeded in finding any recent descriptions or data for this most important find. We have only Pohlig's papers of 1890, 1891 and 1895 (Bibl. 49bis, S. 107, Bibl. 49bis, second title S. 41 and Bibl. 68ter, S. 149). His account is wholly descriptive. In the first paper he promises "eine genaue Abbildung." In the second paper we have a rough drawing of the proximal end of the femur only, the dimensions of which drawing are about 0·75″ × 0·6″, which Pohlig describes as "Beigabe der ersten richtigen Abbildung"—and gives no reference to Kaup's Plate, who at least gives the whole femur, although he reverses it! Even the scale of Pohlig's rough drawing is not provided, so that no absolute measurements can be made upon it. We made on the drawing a few index determinations, etc. which we give below accompanied by the measurements given by Bumüller (B) and Klaatsch (K) and in square brackets our own values from the cast.

Collar Angle	122° [125°·5]
100 × Vertical Diameter of Head/Capito-Collar Length	56·9 [55·4]
100 × Length of Neck(1)/Capito-Collar Length	66·3 [72·3]
100 × Length of Neck(2)/Capito-Collar Length	56·9 [?]
(Length of Neck from base of Head to (1) Coaxial Point, (2) Spiral Line.)	
100 × Vertical Diameter of Neck/Vertical Diameter of Head ...	73·3 [70·0]
100 × Vertical Diameter of Neck/Length of Neck(1)	62·9 [53·5]
100 × Pilastric Circumference/Diaphysial Length (B)	22·3 [?]
Pilastric Index (B)	100 [98·3]
Popliteal Index (B)	65·4 [63·5]
Index of Distal Taper (B)	94·4 [89·9]
Index of Gracility (Lower) (B)	69·3 [69·4]
Maximum Length Lateral Condyle (K)	29·0 [31·0]
„ „ Mesial Condyle (K)	30·0 [30·0]
Condylar Lengths Index (K)	96·7 [103·3]
Condylar Index ((B) says same as that of Gibbon)	72·9 [75·4]
Bicondylar Width (deduced from (B))	39·8 [41·1]

Such appears to be the result of the "erste richtige Abbildung" and what German science has done for this most important bone! And yet some English investigators appear to have a slavish admiration for the products of German research!

much higher Condylar Lengths Index, approaching the higher values of the existing *Cebidae*. Of course the *Tetraprothomo* value falls only a little short of what we might expect in a fossil ancestor of the Greater Anthropoids, but apart from the fact that traces of these Anthropoids, fossil or recent, are lacking in America, the Monte Hermosa femur is by no means the type of femur our present investigation leads us with some plausibility to suggest for the protsimio-human—*it is not human enough*[1]. We discard therefore Ameghino's suggestion of a prot-homo in the New World, and shall believe that America did not get much further than the *Cebidae* in the upward ascent of the primates, until much more human (or anthropoid) links are found there than the Monte Hermosa femur.

The position of *Pithecanthropus erectus* in the Condylar Lengths Index may be largely due to its queried value. Bumüller gives only "91 to 94," sufficiently in accordance with our independent determination under the circumstances. Thus placed it stands in Condylar Lengths Index close either to our own gibbon results, or to the average of five other gibbons, but we would remark still within the human range, and inside the not very improbable human range[2]. At any rate the point, such as it is, is only very slightly in favour of Bumüller's view of the Trinil femur as that of a new species of gibbon—*Hylobates giganteus*—and of Klaatsch's argument from the condyles of its pithecoid and non-human character. But to emphasise the few *slight* pithecoid at the expense of the many *average* human characters of the Trinil femur is to overlook the fact that most human femora differ from the mean human femur and will show in a few characters deviations considerably greater than those found for a few characters in *Pithecanthropus erectus*. If, say 100 characters are taken on any single bone, then we should expect at least two of them to depart from type by twice the standard deviation of the character, and this is precisely what occurs in the present case. We must add to this that these slight deviations from human type are gibbonwards and not troglodytic as we should anticipate personally in any protsimio-human.

(vi) *The Condylar Indices.*

The Condylar Index = 100 × Maximum Length of External Condyle/Bicondylar Width is taken as a natural measure of the relation of the sagittal to the transverse dimensions of the distal epiphysis. The maximum length is of course not truly sagittal and in this respect it might be better to take the projective length which is the value taken by Bumüller. We can give both for our material. We will term them Primary and Secondary Condylar Indices and give both where possible, although in the case of some authorities it is, as we have seen, difficult to say whether they have measured the natural or the projective length.

[1] Compare the results reached in our Chapter X.

[2] The range in man is from 86 to 114 and 19 °/₀ are as divergent in Condylar Lengths Index as the Trinil femur.

TABLE L. *Primary and Secondary Condylar Indices.*

	Group	Primary Index	Secondary Index	Source of Material
Lemuroidea	*Lorisinae* (6)	68·7	65·4	Pearson and Bell
	Chiromyrdae (2)	88·7	80·9	,,
	Lemurinae (18)	103 0 Mean 99·10	93·8 Mean 91·48	,,
	Galaginae (6)	104·3	96·5	,,
	Indrisinae (8)	110·3	102·9	,,
	Tarsiidae (2)	119·6	109·4	,,
Cebidae	*Lagothrix* (2)	59·55	57·0	Pearson and Bell
	Cebus (6)	71·6	68·6	,,
	Mycetes (2)	72·95 Mean 75·49	69·1 Mean 71·73	,,
	Ateles (4)	73·25	71·7	,,
	Brachyurus (2)	78·4	74·4	,,
	Pithecia (2)	77·95	75·6	,,
	Nyctipithecinae (8)	84·1	79·2	,,
	Hapalinae (16)	86·1	78·2	,,
Simiadae	*Macacus* (14)	81·7	79·7	Pearson and Bell
	Semnopithecus (10)	83·6 Mean 85·15	80·7 Mean 82·31	,,
	Cynocephalus (8)	84·8	82·8	,,
	Cercopithecus (8)	87·0	83·6	,,
	Cercocebus (4)	88·65	84·75	,,
New World Monkeys (4) ...		—	76·3	Hrdlička*
Dryopithecus rhenanus (1) ...		75·4†	71·05	From cast
Simiinae	Gorilla (7)	60·7	59·8	Pearson and Bell
	Chimpanzee (2)	62·65 Mean 63·35	59·8 Mean 61·8	
	Orang-utan (5)	66·7	65·7	
	Gibbon (2)	74·4	69·1	
Pithecanthropus erectus (1) ...		79·7	79·5	From photographs
Recent Man	Javanese (1)	—	70·7	Klaatsch‡
	Negrito (1)	—	75·7	,,
	Fuegians (9)	—	76·6	Hultkrantz
	Veddah (1)	—	76·9	Klaatsch
	17th century Londoners ...	♂ 78·08 (389) ♀ 79·91 (283)	♂ 77·04 (416) ♀ 79·26 (299)	Pearson and Bell
	Modern Bolognese	—	♂ 77·6 (20) ♀ 78·2 (23)	Zanolli§
	Malay (1)	—	77·6	Klaatsch
	Gilbert Islander (1)	—	78·3	,,
	Bavarians	—	♂ 78·9 (12) —	Bumüller
	Australians (4)	♂ 82·6 (2) ♀ 81·9 (2)	♂ 81·85 (2) ♀ 80·95 (2)	Pearson and Bell
Primogenial Man	Spy (1)	78·7	77·1	From cast‖
	Neanderthal (1)	83·9 Mean 82·8	82·8 Mean 80·5	,,
	La Chapelle-aux-Saints (1) ...	[84·2?]	—	From photographs
	Homo mousteriensis (Hauseri) (1)	84·5?	81·6	From cast
Mammals	*Tetraprothomo* (Ameghino) (1)	—	89·5	Hrdlička
	Ancient American *Felidae* (5)	—	91·4	,,
	Ancient American *Canidae* (3)	—	93·4 Mean 95·4	,,
	Modern American *Felidae* (5)	—	96·7	,,
	Hyena striata (1)	—	100·0	,,

* We have assumed Hrdlička to have measured the oblique length of the lateral condyle. He gives a "Breadth-depth Index of lower Extremity," but this is based on what he terms the "Maximum antero-posterior diameter of the lower extremity." This, as in the case of three out of four monkeys, can be less than the maximum antero-posterior diameter of the mesial condyle. We prefer in our ignorance of what this diameter signifies to use what we take to be his measures of the oblique length of lateral condyle and of the bicondylar width.

† Bumüller states that the Condylar Index (72 to 73) "würde mit Hylobates übereinstimmen." Bibl. 81, p. 115.

‡ With some hesitation we assume Klaatsch to have measured the oblique length.

§ Zanolli also gives the index 100 × Maximum antero-posterior diameter of Mesial Condyle/Bicondylar Width, ♂ 76·5 (20), ♀ 77·1 (23). Presumably this is the *Secondary* Index of the Mesial Condyle.

‖ From measurements given by Klaatsch, source not stated, we find Neanderthal R. 80·5, L. 81·6, Spy I 80·0. We have thought it safer, however, to retain our own measurements of the cast. Fraipont's 55 for "Diamètre antéro-postérieur du Condyle" of Spy gives us nothing in the way of an index which can be trusted.

Summary for Primary and Secondary Condylar Indices of the Primates.

	Family	Primary Index	Secondary Index
	Lemuroidea (42)	99·10	91·48
	Cebidae (42)	75·49	71·73
	Simiadae (44)	85·15	82·31
Simiinae	Hylobates (*Dryopithecus rhenanus* (1) ...	75·4	71·05
	Hylobates (Gibbon (2)	74·4	69·1
	Hylobates ([*Ateles* (4) (for comparison) . .	73·25	71·7]
	Greater Anthropoids	63·35	61·8
Hominidae	Neanderthal Type	82·8	80·5
	Recent Man (Mean 11 groups) ...	—	76·98
	„ „ (17th century Londoners)	♂ 78·08 (389)	♂ 77·04 (416)
		♀ 79·91 (283)	♀ 79·26 (299)
	„ „ „ „	♂ + ♀ 79·00	♂ + ♀ 78·15

This table is as suggestive as that found for the Condylar Lengths Index. We see again the drop from the Lemuroids, through *Simiadae* to the Greater Anthropoids, then the apparent rise to the Neanderthal Type and the slight-apeward fall in Recent Man. In the case of the New World Monkeys the fall has been greater than in the Old World Monkeys. We interpret this again as in the previous case. For these features of the distal epiphysis man is more primitive than the Greater Anthropoids. He is closer than they are, and indeed closer than the fossil or recent gibbons are to the *Simiadae*. If the fossil Chimpanzee could be found we imagine that the Primary Index would be about 83 to 84 and then we should see a continuous descent of the index from Lemuroids, to the branch point of the *Simiadae*, to Prot-simio-human, to Neanderthal Man, to Recent Man. The lowness of the index in *Cebidae* and the Greater Anthropoids is *recent* and not primitive.

The reader will remark that, as judged by the Secondary Index, Hrdlička's values for *Canidae* and *Felidae*[1] place the mammals above the *Lemuroidea*. The "squareness" of the aspect of the femur in the standard horizontal plane has been replaced in the upward course of evolution by a rectangular aspect, the long axis being transverse.

That the position of the gibbons is due to the essential need of agility appears to us again confirmed by their close relation to *Ateles*. *Pithecanthropus erectus* falls well within the range of Recent Man and is separated from the gibbon by Recent Man.

We may make the following classes:

Hypostenobasic	below 70	Greater Anthropoids,
Stenobasic	70 to below 80	*Cebidae*, Gibbons and Recent Man,
Mesobasic	80 to below 90	*Simiadae* and Primogenial Man,
Eurybasic	90 to below 100	*Canidae* and *Felidae*,
Hypereurybasic	over 100	Certain of the *Lemuroidea*.

Both our Londoners and Zanolli's Bolognese show the male more stenobasic than the female.

[1] It will be noted that Ameghino's *Tetraprothomo* has followed the ancient American *Felidae* to their position in this table.

(vii) *The Condylar Trochanteric Index; Condylar Femoral Length Ratios.*

We need a measure of the ratio of antero-posterior dimension of the distal epiphysis to the absolute size of the femur. We considered that the maximum length of the lateral condyles and the maximum length of the femur would have been the best measures on which to base such an index. Klaatsch, however, who had been among the first to grasp the importance of such an index selected the "length of the lateral condyle" and the trochanteric length of the bone. We can give both indices for our own data, but if we are to have any, however slender, comparative material we must use Klaatsch's form of this index. Unfortunately we cannot find that Klaatsch has adequately defined his "Kondylenlänge." If he is following Bumüller it should be the *oblique* length for the Condylar Index, and the *natural* lengths in the Condylar Lengths Index and when the discussion turns on the difference of lateral and mesial condyle lengths. In choosing our own index, we thought Klaatsch meant by "Kondylenlänge" the natural length (see our p. 401), and accordingly in our Table II, p. 116, and in our Table of Measurements of the Femora of Primogenial Man and Comparatives in Chapter X, we have provided the ratio of the natural length of the External Condyle to the Trochanteric Length. We will term this the Secondary Condylar Trochanteric Index. The Primary Trochanteric Index shall be the ratio of the Oblique Length of Lateral Condyle and the Trochanteric Length. We are not certain whether Klaatsch wants to find the Primary or the Secondary but he gives what he calls the proportion of Condyle Length to Trochanteric Length, and this in his view really consists in dividing the latter by the former. Hultkrantz tables what he calls the "Dicke des condyl. lateralis" and refers somewhat vaguely to Martin's paper on the Fuegians, Lehmann-Nitsche's paper on the long bones of the Row Graves, and Schmidt's *Anthropologische Methoden*, Leipzig, 1888, for further details of his methods of measurement. Klaatsch considers Hultkrantz's measurements identical with his own. Lastly we may take the first index suggested in this paragraph—which we believe to be the soundest—namely, that based on the ratio of Natural Length of Condyle to Maximum Femoral Length; we shall term this the Tertiary Index. This diversity of indices only indicates the crying need for standardisation in femoral measurements. On the other hand it is relatively easy to find factors which will satisfactorily reduce our indices to Klaatsch's or *vice versa* in the case of man. We take our standards from our London series which is the only series of adequate length for such a purpose. We find[1]:

$$\frac{\text{Maximum Length}}{\text{Trochanteric Length}} = 1{\cdot}0486\,♂\,\text{R.},\ = 1{\cdot}0520\,♂\,\text{L.},\ = 1{\cdot}0525\,♀\,\text{R.},\ = 1{\cdot}0508\,♀\,\text{L.}$$

These are so closely in accord[2] that we can take their mean 1·051 as a reducing factor

[1] See Table I, p. 115.

[2] Neanderthal and Spy both give the ratio 1·0481, La Chapelle-aux-Saints 1·0474, and only *H. mousteriensis* (*Hauseri*) with a doubtful Trochanteric Length gives 1·0322. We may take it to be for Primogenial Man 1·048, which agrees to 3 in the 1000 with the value for Recent Man.

for an index based on the Maximum Length in order to obtain an index based on the Trochanteric Length and ·951 for an index based on the Trochanteric Length to find one based on the Maximum Length.

Again we have:

$$\frac{\text{Maximum Length Lateral Condyle}}{\text{Oblique Length Lateral Condyle}} = 1{\cdot}0152\ \text{♂ R.},\ = 1{\cdot}0171\ \text{♂ L.},$$
$$= 1{\cdot}0109\ \text{♀ R.},\ = 1{\cdot}0119\ \text{♀ L.},$$
$$= 1{\cdot}016\ \text{♂ (R. + L.)},\ = 1{\cdot}011\ \text{♀ (R. + L.)},\ = 1{\cdot}014\ (\text{♂ + ♀, R. + L.}).$$

The ratios are not so nearly equal here as in the first case, but as the majority of authors do not state for the indices in question either sex or side of the femora dealt with, we must perforce be content with 1·014, or in the case of the reciprocal ·986.

Thus:

$$\text{Primary Index} = \frac{100\ \text{Oblique Length of Lateral Condyle}}{\text{Trochanteric Length of Femur}}$$
$$= \text{Secondary Index} \times \left(\frac{\text{Oblique Length of Lateral Condyle}}{\text{Maximum Length of Lateral Condyle}}\right) \times \left(\frac{\text{Maximum Length of Femur}}{\text{Trochanteric Length of Femur}}\right)$$
$$= \text{Secondary Index} \times {\cdot}986 \times 1{\cdot}051 = 1{\cdot}036 \times \text{Secondary Index},$$

and

$$\text{Secondary Index} = {\cdot}965 \times \text{Primary Index}.$$

The justification for putting in the mean values of the ratios of the condyle lengths and the femoral lengths depends upon the principle illustrated in our Chapter IV, Table III, p. 121. Each ratio does not make more than a small percentage change and if we neglect the squares and products of the individual variation from these small changes, we obtain the above result on taking mean values. Thus let I_P be the mean Primary Index, $\bar{I}_S$ the mean Secondary Index, $\bar{R}_C$ the mean condyle lengths ratio, $\bar{R}_L$ the mean femoral lengths ratio; ΔI_P, ΔI_S, ΔR_C, ΔR_L the variation from the means for any individual. Then we have accurately:

$$\bar{I}_P + \Delta I_P = (\bar{I}_S + \Delta I_S)(\bar{R}_C + \Delta R_C)(\bar{R}_L + \Delta R_L)$$
$$= \bar{I}_S\, \bar{R}_C\, \bar{R}_L \left(1 + \frac{\Delta I_S}{\bar{I}_S} + \frac{\Delta R_C}{\bar{R}_C} + \frac{\Delta R_L}{\bar{R}_L} + \begin{matrix}\text{square terms involving pro-}\\ \text{ducts of small quantities}\end{matrix}\right).$$

Hence summing for a series:

$$\bar{I}_P = \bar{I}_S\, \bar{R}_C\, \bar{R}_L$$

if we may neglect terms of the order of $\frac{1}{(100)^2}$ (product of coefficients of variation × corresponding coefficient of correlation) compared with unity, and such neglect is usually permissible. If we apply the formula to *an individual* instead of to a series we have:

$$\text{Primary Index} = \text{Secondary Index} \times \bar{R}_C \times \bar{R}_L \times \left(1 + \frac{\Delta R_C}{\bar{R}_C} + \frac{\Delta R_L}{\bar{R}_L} + \ldots\right),$$

TABLE LI. *Condylar Femoral Length Ratios.*

Group	Primary Index $= \frac{100\left(\text{Oblique Length lateral Condyle}\right)}{\text{Trochanteric Length}}$	Secondary Index $= \frac{100\left(\text{Maximum Length lateral Condyle}\right)}{\text{Trochanteric Length}}$	Tertiary Index $= \frac{100\left(\text{Maximum Length lateral Condyle}\right)}{\text{Maximum Femoral Length}}$	Source of ultimate data for indices
Lemuroidea				
Lorisinae (6)	10·4	10·75	10·8	Pearson and Bell
Indrisinae (8)	11·7	12·6	12·65	,,
Tarsiidae (2)	11·8 Mean 12·03	12·9 Mean 13·05	12·85 Mean 13·10	,,
Chiromyrdae (2)	12·2	13·35	13·2	,,
Lemurinae (18)	12·6	13·8	14·1	,,
Galayinae (6)	13·5	14·9	15·0	,,
Cebidae				
Brachyurus (2)	9·6	10·15	10·05	Pearson and Bell
Pithecia (2)	10·0	10·25	10·1	,,
Ateles (4)	10·8 Mean 11·03	11·05 Mean 11·62	10·8 Mean 11·49	,,
Cebus (6)	10·9	11·4	11·4	,,
Lagothrix (2)	11·4	11·9	11·7	,,
Nyctipithecinae (8)	11·7	12·5	12·4	,,
Mycetes (2)	11·9	12·6	12·35	,,
Hapalinae (16)	11·9	13·1	13·1	,,
Simiadae				
Cercocebus (4)	11·2	11·7	11·9	Pearson and Bell
Semnopithecus (10)	11·5 Mean 12·40	12·05 Mean 12·82	12·4 Mean 13·01	,,
Cynocephalus (8)	12·9	13·25	13·35	,,
Macacus (14)	13·3	13·5	13·7	,,
Cercopithecus (8)	13·1	13·6	13·7	,,
Dryopithecus rhenanus (1) ...	10·3	10·9	10·8	From cast
Simiinae				
Orang-utan (5)	15·1	15·3	14·1	Pearson and Bell
Gorilla (7)	14·9 Mean 14·43	14·8 Mean 14·68	14·8 Mean 14·23	,,
Chimpanzee (2)	13·3	13·95	13·8	,,
Gibbon (2)	9·1	9·4	9·3	,,

	Group	Primary Index $= \frac{100\left(\text{Oblique Length}\right)}{\text{Trochanteric Length}}$	Secondary Index $= \frac{100\left(\text{Maximum Length}\right)}{\text{Trochanteric Length}}$	Tertiary Index $= \frac{100\left(\text{Maximum Length}\right)}{\text{Maximum Femoral Length}}$	Source of ultimate data for indices
	Pithecanthropus erectus (1) ...	14·2	14·2	13·7	Photographs
Recent Man	Negrito (1)	13·4	13·6	12·9	Klaatsch*
	Veddah (1)	13·9	14·1	13·4	,,
	Malay (1)	14·2	14·4	13·7	,,
	"Germans" (3)	14·24	14·44	13·74	,,
	Javanese (1)	14·3	14·5	13·8	,,
	17th century Londoners ...	♂ 14·43 (396) ♀ 14·26 (299)	♂ 14·67 (396) ♀ 14·48 (283)	♂ 13·96 (389) ♀ 13·71 (283)	Pearson and Bell
	Modern Bolognese	♂ 14·76 (20) ♀ 14·62 (23)	♂ 14·97 (20) ♀ 14·83 (23)	♂ 14·45 (20) ♀ 14·31 (23)	Zanolli
	Bavarians (?)	♂ 14·89 —	♂ 15·10 —	♂ 14·37 —	Bumüller
	Fuegians (10)	14·97	15·18	14·61	Hultkrantz
	Gilbert Islander (1)	15·3	15·5	14·8	Klaatsch
	Australians	♂ 15·5 (2) ♀ 15·65 (2)	♂ 15·5 (2) ♀ 15·65 (2)	♂ 14·6 (2) ♀ 14·95 (2)	Pearson and Bell
	Neanderthal (1)	17·4†	17·7†	16·8	From cast
	Spy (1)	17·3‡	17·7‡	17·2	,,
	Homo mousteriensis (*Hauseri*) (1)	18·3?	18·9?	18·3?	,,
	La Chapelle-aux-Saints (1) ...	17·0?	17·2?	16·4?	From photographs
	Galley Hill	> 15·1	> 15·8	> 15·1	From cast

* We have actually taken, to obtain some definiteness in this table, Klaatsch's data to give the Secondary Index. If they really give the Primary Index, they must be transferred to the first column and we shall obtain the Secondary Index fairly closely by adding 0·2 to their values and the Tertiary Index by subtracting 0·7.

† Klaatsch gives condyle length and trochanteric length of both Neanderthal femora, and they lead to R. 16·7, L. 16·7. It is doubtful whether they are for the Primary or Secondary Index.

‡ Klaatsch gives condyle length and trochanteric length of Spy leading to the index 17·6, which agrees best with our Secondary Index.

and the accuracy of the interchange is much lessened owing to the fact that we shall now be neglecting terms of the order $\frac{1}{100}$ (sum of coefficients of variation) compared with unity, and this is less permissible, causing in the work we are doing changes of perhaps 2 °/₀ to 4 °/₀. It is the best possible, however, under the circumstances, *i.e.* until femoralogists have realised the importance of drawing conclusions only from fairly long series[1].

The table on pp. 416–417 contains all the material bearing on the proportion of condyle to absolute femoral size that we can find.

Had we taken the Secondary Index for Londoners and deduced the Primary and Tertiary Indices from it by our reducing factors we should have found

Primary Index	Tertiary Index
♂ 14·46, ♀ 14·28,	♂ 13·96, ♀ 13·77,

reasonably satisfactory values. Of course the reduction factors for man must not be applied to the apes, although as we have indicated they seem fairly reasonable for Primogenial Man. Accordingly we do not think it of any importance which lateral condyle length and which femoral length is taken for the specification of this index. The indices do not differ much from each other and retain the same serial order. But it is essential to standardise the index, and for each osteometrician to state exactly what he has given. We believe that very little is to be gained by taking the Trochanteric Length instead of the maximum. We took it on the authority of Klaatsch but as in the cases of the Proximal and Distal Breadth Ratios have found no advantage in it. The maximum length of the condyle is easier to take than the oblique length,

[1] We would ask the reader to remember that merely multiplying by such factors does not represent the whole work put into this table or other tables of this chapter. We have had to use all sorts of artifices to deduce the characters we need. We do not state this in order to emphasise the great labour put into these tables, but to warn the reader that in many cases he will not be able to verify our results by merely referring to the authors cited. The following instance will illustrate this and it is by no means an exceptional case. Bumüller does not give either the absolute Condyle Length or the Trochanteric Length of his Bavarian material. Nor does he give the Bicondylar Width. He does give the Maximum Femoral Length (450·16) and the Diaphysial Length (385·0). He tells us that

$$100 \times \text{Bicondylar Width/Diaphysial Length} = 21{\cdot}0\,;$$

hence we reconstructed the Bicondylar Width in *mms.* as 80·85. Further he gives the Condylar Index as 78·9; thus we have: 100 Oblique Length of Lateral Condyle/Bicondylar Width = 78·9. From this we reconstructed the Oblique Length of Lateral Condyle as 63·79. We were now able to obtain the Index: 100 × Oblique Length of Lateral Condyle/Maximum Length of Femur = 14·17. In order to get the Primary Condylar Trochanteric Index we have now to multiply by the factor 1·051; thus the value for that index for *male* Bavarians to whom the above values apply is 14·89, and the Tertiary Index will be 14·37. The reader would search in vain for such indices in Bumüller's monograph! The warning is very essential for the Tables of Racial Values issued from the Biometric Laboratory are largely reconstructed in this manner. We have recently had occasion to notice whole tables of racial craniometric values annexed from our cranial memoirs without acknowledgment. The values being cited as if the authors of the memoirs from which we took the original data had themselves provided our means or our indices. Thus we shall no doubt see quoted values of the Condylar Trochanteric Index as due to Bumüller, Zanolli, or Klaatsch, abstracted actually from our table. It is not fair to make these authors responsible for reconstructions of which they might not approve, and for which the reader will search vainly in their papers, even if it does save the inert appropriator from the trouble of reading the original memoirs.

the latter for accuracy requiring special apparatus for it cannot be effectively determined by the calipers alone. We used the osteometer board and a vertical gauge. Perhaps then it is best to recommend all femoralogists to concentrate on the Tertiary Index.

Summary of Table LI. *Condylar Femoral Length Ratios.*

Family			Primary Index	Secondary Index	Tertiary Index
Lemuroidea (42)			12·03	13·05	13·10
Cebidae (42)			11·03	11·62	11·49
Simiadae (44)			12·40	12·82	13·01
Simiinae	Hylobates	*Dryopithecus rhenanus* (1) ...	10·3	10·9	10·8
		Gibbon (2)	9·1	9·4	9·3
		[*Ateles* (4) (for comparison) ...	10·8	11·05	10·8]
		Greater Anthropoids (14) ...	14·43	14·68	14·23
Hominidae		Neanderthal Type	17·5	17·9	17·2
		Recent Man (12 groups)	14·27	14·65	13 98
		Recent Man (17th century Londoners)	14·34	14·57	13·84

This table is of special interest as indicating extremely small difference between Lemuroids and *Simiadae*. The *Cebidae* fall on the Lemuroids and so does *Hylobates*, here closely mimicked by *Ateles*. The hesitation of *Simiadae* to fall in sympathy with *Cebidae* is explained by the continued rise in the Greater Anthropoids and in Man. Primogenial Man in the Neanderthal Type appears to have an exaggerated distal sagittal breadth relative to his femoral length. This apparently was corrected in Galley Hill and almost certainly in the Cromagnon Type for which we can find no single measurement of the condyles. The outstanding point is as usual what values to give to the Protsimio-human and the ancestors of the Greater Anthropoids. We expect something from 15 to 16[1], the maximum would then be reached in some ancestor of the Greater Anthropoids and in Neanderthal Man. Recent evolution would then show a falling relative condylar length in *Cebidae*, in *Hylobates*, in the recent Greater Anthropoids and in Recent Man. The fact that Recent Man is closer to the Anthropoids, particularly to the Chimpanzee, than to Neanderthal Man is not we believe an argument that he has not passed through a Neanderthal Stage—it is rather that the Neanderthal Stage for the Greater Anthropoids is at present missing. It emphasises the immense importance which would accompany the discovery of a fossil Chimpanzee.

Now what has the present table, notwithstanding its pitiably slender material, to teach us with regard to Recent Man? If we could really trust to basing any conclusion on Klaatsch's measurements of isolated individuals we should once more find modern Europeans in the centre of the human group flanked by primitive races on the one side approaching the pithecoid, as Malay, Veddah and Negrito, and on the

[1] Of course there is a wide range of variation in this as in other indices, and no *single* index on a *single* bone would suffice to prove or disprove our suggestion.

other Primogenial Man, as in the Fuegians. It is sad beyond measure that we have no Eskimo, Aino, Moriori or other fringe races and no Negroes or North American Indians, to strengthen our table. *Pithecanthropus erectus* is absolutely "recent man" in this character and has an index sensibly the same as that of a Javanese or Malay. It may also be said that the Trinil femur falls into the ape range. If so it is gorilloid and very remote from the gibbon, but as it certainly is not gorilloid in other features we much prefer the view that in this, as in most other characters, it is Recent Man, and, what is more, Asiatic Man.

Slope of the Condyles to Standard Sagittal Plane.

We will conclude this section dealing with the condylar lengths by a reference to the orientation of the condyles. We regret very much not having taken *ab initio* for the whole of our series the oblique length of the mesial condyle as well as that of the lateral condyle. The latter was taken because it had been used in the condylar index by Bumüller. The slope, however, of the mesial condyle to the standard sagittal plane is greater than that of the lateral condyle, although it appears in the primates to be less variable; it is possibly a more marked intraracial character in man than the slope of the lateral condyle and accordingly it would be better worth studying, but we have no material by which to determine this point. Owing to the desire to limit the characters studied[1] this character was rejected when planning our work. It has only been as the femur grew more and more familiar to us and we realised more fully the importance of its several characters not only as criteria for human races, but in their relationship to the like characters in other primates, that we have concluded that it would be wise in future to give more attention to certain characters we have neglected and less to others that we have spent energy on. Our excuse must be that we put too great faith in what previous writers—without much quantitative proof—had asserted to be important, and that not until we had ourselves dealt with them was it possible to realise that a better selection of characters could have been made. At any rate we consider the slope of the mesial condyle deserves a full study, when there are again men who have freedom without self-reproach to turn to problems of pure research. We were only able to measure the oblique length of the mesial contour in about $\frac{1}{5}$ of our material.

(viii) *Condylar Obliquity Index and Condylar Obliquity.*

Clearly the ratio of oblique to maximum length of condyle will measure in a rough way its slope to the standard sagittal plane. It does not measure it accurately, because while the oblique length is strictly perpendicular to the standard vertical plane, and so parallel to the standard horizontal plane, the maximum length of the condyle is not strictly but only roughly in a plane through the oblique length parallel to the standard horizontal plane and so perpendicular to the standard sagittal. Indeed much

[1] We may remind the reader that our tables contain over 80 absolute and indicial characters, and that at least 20 to 30 others not in the tables are discussed at various points of the text. We were more than eight years over the measurements and reductions and some limitation was absolutely necessary.

TABLE LII. *Condylar Obliquity Indices and "Obliquity" of Condyles.*

	Group	Lateral Condyle: Condylar Obliquity Index	Lateral Condyle: "Obliquity" of Lateral Condyle	Group	Mesial Condyle: Condylar Obliquity Index	Mesial Condyle: "Obliquity" of Mesial Condyle
Lemuroids	*Galaginae* (6)	89·13	26° 58′	*Galaginae* (6)	86·11	30° 33′
	Chiromyrdae (2)	91·21	24° 12′	*Lorisinae* (6)	89·47	26° 32′
	Lemurinae (18)	91·21	24° 12′	*Lemurinae* (18)	92·35	22° 33′
	Tarsiidae (2)	91·52	23° 46′	*Tarsiidae* (2)	92·77	21° 55′
	Indrisinae (8)	93·75	20° 22′	*Chiromyrdae* (2)	96·41	15° 24′
	Lorisinae (6)	94·58	18° 56′	*Indrisinae* (8)	96·81	14° 31′
		Mean 91·90	Mean 23° 4′·3		Mean 92·32	Mean 21° 54′·7
Cebidae	*Hapalinae* (16)	91·33	24° 2′	*Mycetes* (2)	90·98	24° 31′
	Nyctipithecinae (8)	93·64	20° 33′	*Cebus* (6)	92·55	22° 15′
	Mycetes (2)	94·67	18° 47′	*Lagothrix* (2)	92·57	22° 14′
	Brachyurus (2)	94·87	18° 26′	*Nyctipithecinae* (8)	92·66	22° 6′
	Cebus (6)	95·59	17° 5′	*Hapalinae* (16)	92·68	22° 4′
	Lagothrix (2)	95·80	16° 40′	*Ateles* (4)	93·07	21° 27′
	Pithecia (2)	96·95	14° 11′	*Pithecia* (2)	94·57	18° 58′
	Ateles (4)	97·93	11° 41′	*Brachyurus* (2)	95·35	17° 34′
		Mean 95·10	Mean 17° 40′·6		Mean 93·05	Mean 21° 23′·6
Simiadae	*Semnopithecus* (10)	93·98	19° 59′	*Cynocephalus* (8)	92·71	22° 1′
	Cercocebus (4)	95·60	17° 4′	*Macacus* (14)	92·79	21° 57′
	Cercopithecus (8)	96·92	14° 15′	*Semnopithecus* (10)	92·95	21° 39′
	Macacus (14)	97·47	12° 55′	*Cercocebus* (4)	93·37	20° 59′
	Cynocephalus (8)	99·18	7° 20′	*Cercopithecus* (8)	94·92	18° 20′
		Mean 96·63	Mean 14° 18′·6		Mean 93·35	Mean 20° 59′·2
	Dryopithecus rhenanus ...	94·19	19° 38′	*Dryopithecus rhenanus*	95·33	17° 35′
Simiinae	Chimpanzee (2)	95·51	17° 14′	Orang-utan (5)	86·89	29° 40′
	Gibbon (2)	96·94	14° 13′	Chimpanzee (2)	88·25	28° 3′
	Gorilla (7)*	98·51	9° 54′	Gorilla (7)	91·40	23° 56′
	Orang-utan (5)	98·80	8° 53′	Gibbon (2)	91·91	23° 12′
		Mean 97·44	Mean 12° 33′·5		Mean 89·61	Mean 26° 12′·7
	Pithecanthropus erectus (1) ...	99·68?	4° 36′?	*Pithecanthropus erectus* (1) ...	95·31?	17° 37′?
	Galley Hill (1)	[95·16??]	[17° 54′??]	Galley Hill	—	—
	Homo mousteriensis (*Hauseri*) (1)	96·59?	15° 0′	*Homo mousteriensis* (*Hauseri*) ...	—	—
	Spy (1)	97·97	11° 35′	Spy	—	—
	Neanderthal (1)	98·67	9° 21′	Neanderthal	—	—
		Mean 97·74	Mean 11° 59′			
	17th century Londoners ♂ ...	98·41	10° 13′	17th century Londoners ♂ ...	91·97	23° 7′
	,, ,, ♀ ...	98·86	8° 40′	,, ,, ♀ ...	93·51	20° 45′
		Mean 98·63	Mean 9° 26′		Mean 92·74	Mean 22° 27′·5

* It is noteworthy how small is the sexual difference of these indices not only in Man, but in the Gorilla, where we have ♂ 98·56 and 91·26, ♀ 98·45 and 91·59.

the same objections may be raised to this measure of the slope of the condyle as to Warren's pseudo-obliquity: see our p. 31. All we can say is that in a roughly approximate way, if we take $\cos\theta$ = oblique length of condyle/maximum length of condyle, θ will measure the slope of the condyle to the standard sagittal plane. We may term $100\cos\theta$ the condylar obliquity index and θ itself the condylar obliquity. The following table gives our own data for the Condylar Obliquity Index and for the Obliquity of both Condyles in the primates.

Summary of Results for Condylar Obliquity.

Family	Condylar Obliquity Index		Obliquity	
	Lateral Condyle	Mesial Condyle	Lateral Condyle	Mesial Condyle
Lemuroids (42)	91·90	92·32	23° 4′·3	21° 54′·7
Cebidae (42)	95·10	93·05	17° 40′·6	21° 23′·6
Simiadae (44)	96·63	93·35	14° 18′·6	20° 59′·2
Simiinae (16)	97·44	89·61	12° 33′·5	26° 12′·7
Dryopithecus rhenanus (1)	94·19	95·33	19° 38′	17° 35′
Recent Gibbon (2)	96·94	91·91	14° 13′	23° 12′
[*Ateles* (4) (for comparison)	97·93	93·07	11° 41′	21° 27′]
Neanderthal Man (3)	97·74	—	11° 59′	—
Recent Man (17th century Londoners)	98·63	92·74	9° 26′	22° 27′·5

Now this table shows us that the slopes to the sagittal standard plane of lateral and mesial condyles have followed different lines of evolution. Among the Lemuroids, the slope of the two condyles are almost equal; indeed in only two genera—*Galaginae* and *Lorisinae*—is the obliquity of the mesial condyle the greater. In the four remaining genera it is very considerably less. The result is that in the Lemuroids as a whole the lateral condyle has on the average a slightly greater slope than the mesial. In the *Cebidae* all but two genera—the *Hapalinae* and *Brachyurus*—have the obliquity of the mesial contour the greater, and the mean slope of the mesial condyle is substantially greater than that of the lateral condyle for the family. In the *Simiadae* no genera have the obliquity of the mesial condyle greater than that of the lateral condyle, and the difference of the mean slopes is still further increased. In the *Simiinae* in all cases the mesial condyle has the greater obliquity, and the average value is just double the slope of the lateral condyle. This development is continued in Recent Man until the slope of the mesial condyle is nearly 150 °/₀ above that of the lateral condyle. Looked at in broad lines the evolution is of the following character—with certain divergences to be referred to immediately—the slope of the mesial contour from the Lemuroids to man has remained right through the lesser apes about 22°, but the slope of the lateral condyle to the sagittal plane instead of retaining its mean Lemuroid value of 22° or 23° has got steadily less and less until it culminates with 9° in the *Hominidae*. In other words the balanced slope of the Lemuroid condyle has been gradually replaced in the case of the lateral condyle only by a slope which is making the plane of that condyle more and more nearly vertical.

We now turn to the divergences just referred to which are concentrated in the *Simiinae*. In the first place we note that neither the recent gibbon nor *Ateles* are

for this character close to *Dryopithecus rhenanus*, although not so widely divergent from each other. *Dryopithecus* has a higher value of the slope of the lateral and a lower value of the slope of the mesial than might reasonably be anticipated. We should *à priori* have expected the fossil gibbon to have condylar obliquities nearer than the recent gibbon to the *Simiadae*, and this is certainly not the case for the lateral condyle. The second unusual phenomenon is the position of the gibbon among the *Simiinae*. It usually occupies a position well apart from the Greater Anthropoids; so far apart that we have not felt justified as a rule in including it in the *Simiinae* mean values[1]. But for the present character the index value for the lateral condyle stands between that of the chimpanzee and gorilla, and for the mesial condyle is sensibly the same as that of the gorilla itself[2]. The curious points are the approach in obliquity of the lateral condyle of the gorilla and the orang, *not* the chimpanzee, to the human value, and again the marked rise in obliquity of the mesial condyle in the case of both orang and chimpanzee. This rise is without parallel in the primates until we get back to the *Galaginae*. In this character at least Recent Man is more "gorilloid" than "orangoid," but judging by the values for Neanderthal Man and Recent Man of the obliquity of the lateral condyle, we have some reason for supposing that Neanderthal Man would tend more in the direction of orang and chimpanzee than in that of gorilla. A further study is certainly needed of why the *Simiinae* in these characters break into groups so different from the usual, and why the groups into which they split differ so much from each other, and have such a peculiar relation to the values for the *Hominidae*. Both values for *Pithecanthropus erectus* are queried values, but in slope of the lateral condyle the Trinil femur is far more nearly human than gibbon-like. In the case of the mesial condyle, that femur is within the human range, and nearer to Recent Man than to the Recent Gibbon, but nevertheless still closer, practically identical with the non-gibbon-like value for the Eppelsheimer femur.

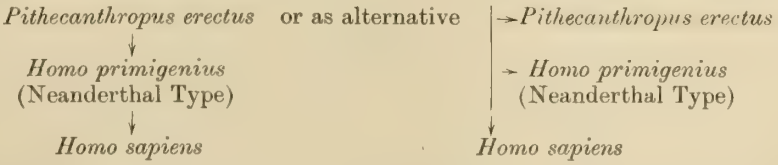
The value for the Galley Hill femur is practically worthless; it is determined from the minimum limits to the condyle lengths. It suggests without proving that the Galley Hill femur would find its parallel rather in the Neanderthal group than in that of Recent Man.

The old fashioned evolutionary order Lemuroids, *Simiadae*, *Simiinae*, Primogenial Man, Recent Man receives some support from this character[3]. As an isolated instance,

[1] This need for separation has been so great that on the basis of the femur alone, we should prefer to place the gibbon in a separate family from the Greater Anthropoids, *e.g.* the *Hylobatinae*.

[2] If we take into account the femur of a third gibbon (*Hylobates lar*) measured by us, the condylar obliquity indices for the three gibbons give 97·07 and 91·39 or obliquities of 13° 54′ and 23° 57′, thus denoting no significant change in position.

[3] The late G. Schwalbe supports (see Bibl. 94ter, S. 166) the descent indicated by



and does not think discussion of the two of much worth. His views are of special importance, because

however, it can have only limited value. At the same time the obliquity of the lateral condyle is a character very probably closely related to uprightness of gait and should be given weight proportional to this import.

(ix) *Study of the Femoral Articular Surface of the Knee-joint.*

A. *Absolute Size.* We have taken two measures of the absolute size, namely (*a*) the Width of the Distal Articulation and (*b*) the Height of the Patellar Articular Surface, which will be more briefly spoken of as Patellar Height. These two measurements are by no means very closely correlated, a great breadth of distal articulation may well be associated with a short patellar surface. For example: *Pithecia* and

TABLE LIII. *Absolute Value of Distal Articulation.*

	Group	Distal Articulation Width		
Lemuroids	*Tarsiidae* (2) ...	6·1	Mean 11·97	
	Galaginae (6) ...	7·7		
	Lorisinae (6) ...	9·7		
	Lemurinae (18) ...	15·9		
	Chiromyrdae (2) ...	16·0		
	Indrisinae (8) ...	16·4		
Cebidae	*Hapalinae* (16) ...	9·0	Mean 17·28	
	Nyctipithecinae (8)	11·6		
	Brachyurus (2) ...	12·15		
	Pithecia (2) ...	15·25		
	Cebus (6)	16·85		
	Lagothrix (2) ...	19·95		
	Mycetes (2)	22·9		
	Ateles (4)	30·5		
Simiadae	*Cercopithecus* (8) ...	20·4	Mean 26·69	
	Macacus (14) ...	26·2		
	Semnopithecus (10)	26·25		
	Cercocebus (4) ...	26·4		
	Cynocephalus (8) ...	34·2		

	Group	Distal Articulation Width	
	Dryopithecus rhenanus	35·3	
Simiinae	Gibbon (2)	22·6	
	Orang-utan (5)	46·8	Mean 60·43
	Chimpanzee (2)	58·3	
	Gorilla (7)	76·2	
	Pithecanthropus erectus	73·0?	
Primogenial Man	Cromagnon Type (5)	82·2	
	Grimaldi Type (2)	77·8??	
	Neanderthal Type (6)	69·5	
	Homo aurignacensis (*Hauseri*) (1)	[64·0]	
Recent Man	17th century Londoners ♂ (73) ...	70·22*	
	„ „ ♀ (62) ...	62·25	

* Our four Australian femora give: ♂ 72·9 (2), ♀ 65·6 (2).

Lagothrix have almost the same patellar heights (6·7 and 6·4) but their distal articulation breadths are very unequal (15·25 and 19·95). Again, Neanderthal Man and the fossil gibbon *Dryopithecus rhenanus* have almost equal patellar heights (16·7 and 16·8) but most unequal distal articulation breadths (69·5 and 35·3). Thus neither articular measurement is in itself a standard of size and their ratio as given by the Rotular Index is a very important generic character within each family. It follows

they are always backed by careful study and are not mere hypothesis. It seems to us, however, that there is important difference between the two alternatives, especially in regard to *Pithecanthropus erectus* Our study of the Trinil femur seems to render it impossible for Neanderthal Man to be a link between *Pithecanthropus erectus* and Recent Man. But Schwalbe worked principally on the crania, and some may find adequate reason in this for separating the Trinil femur from the cranium. Be this as it may our detailed study of that femur makes it in our opinion purely that of Recent Man, and if it be that of the Protsimio-human, then neither Neanderthal Man nor indeed his branch point can well be placed between *Pithecanthropus erectus* and Recent Man.

also that their ratios to the maximum length of the femur—*i.e.* the Distal Articulation Ratio and the Rotular Ratio—are far from proportional and form indeed very marked characteristics of the primates. We can emphasise the distinctions between the genera of the primates by taking the ratio of the patellar height to the diaphysial length, this is the Rotular Diaphysial Ratio, which runs of course nearly parallel with the Rotular Ratio although with higher values[1].

Now if we place any stress on size—and vague and irregular as absolute size is we are compelled to place some stress on it—the continual increase in the distal articulation from Lemuroid to Old World Monkey, to Greater Anthropoid and then to Man is noteworthy. When we come to Man the exaggeration in the case of Cromagnon Man and the reversion of Recent Man to the Neanderthal and therefore to a more apelike value is a sequence which we have had and shall have again occasion to refer to. The Grimaldi Type value is only to be treated as an untrustworthy suggestion. As usual the Trinil femur is merely human, and *Dryopithecus rhenanus* once more indicates that the Recent Gibbon is a specialised form of a more massive femoral type. Conclusions of real value will, however, scarcely be arrived at from absolute sizes. Judging from mean values, however, for this character the *Lorisinae* are nearest to type in the Lemuroid group, *Cebus* in the *Cebidae*, *Cercocebus* in the *Simiadae*, and the Chimpanzee in the Anthropoids.

Our next table provides the corresponding data for the patellar height. The noteworthy point here is that the patellar height for the New World Monkeys is if

TABLE LIV. *Absolute Value of Patellar Surface Height.*

	Group	Patellar Surface Height		
Lemuroids	*Galaginae* (6) ...	5·6		
	Lorisinae (6) ...	5·6		
	Tarsiidae (2) ...	5·9		
	Chiromyrdae (2) ...	7·95		
	Indrisinae (8) ...	10·0		
	Lemurinae (18) ...	12·7	Mean 7·96	
Cebidae	*Hapalinae* (16) ...	4·7		
	Nyctipithecinae (8)	5·6		
	Lagothrix (2) ...	6 4		
	Pithecia (2) ...	6·7		
	Cebus (6)	7·2		
	Mycetes (2) ...	9·6		
	Brachyurus (2) ...	9·75	Mean 7·71	
	Ateles (4)	11·75		
Simiadae	*Cercopithecus* (8) ...	10·6		
	Macacus (14) ...	12·1		
	Semnopithecus (10)	13·6		
	Cynocephalus (8) ...	15·65		
	Cercocebus (4) ...	15·95	Mean 13·58	
	Dryopithecus rhenanus (1)	16·8		
Simiinae	Gibbon (2)	10·95		
	Orang (5)	19·6		
	Chimpanzee (2)	22·6	Mean 22·33	
	Gorilla (7)	24·8		
	Pithecanthropus erectus (1) ...	24·0		
Primogenial Man	Cromagnon Type (5)	25·8		
	Grimaldi Type (2)	30·7 ??		
	Neanderthal Type (6)	16·7		
	Homo aurignacensis (*Hauseri*) (1)	[19·5]		
Recent Man	17th century Londoners ♂ (73) ...	25·81*		
	,, ,, ♀ (62) ...	22·87		

* Our four Australian femora give: ♂ 26·65 (2), ♀ 22·75 (2).

[1] We postpone the discussion as to the difficulties which arise in taking the distal articulation width and the patellar height to the following chapter.

anything slightly *below* that of the Lemuroids, while the Lemuroids, *Simiadae*, *Simiinae* and Man show the same continuous increase in size, and practically maintain the same relative order of genera. *Pithecanthropus erectus* is merely recent manlike, certainly not hylobatic, but Recent Man has retained the full increase of patellar surface height of the Cromagnon Type. Our value for the Neanderthal Type, based solely on photographs and casts, if correct is singularly low, approaching that of the much shorter femur from Eppelsheim. The Chimpanzee and *Cebus* remain respectively the type femora for this character of their respective families, but for the Lemuroids the Aye-Aye replaces the *Lorisinae*, and *Semnopithecus* replaces *Cercocebus* for the *Simiadae*.

More light is likely to result from a consideration of the indices.

B. *Indices.* (*a*) *Distal Articulation Ratio.* We turn first to the size of the distal articulation relative to the size of the femur, *i.e.* to the Distal Articulation Ratio. The following table indicates that the whole aspect of matters changes when we deal with relative instead of absolute size. While the *Cebidae* had not developed an absolute distal articulation as large as the *Simiadae* the mean relative size is the same for the two families, although from *Brachyurus* to *Lagothrix* the *Cebidae* provide a wider range of index values. There is a gradual ascent in index from Lemuroids to Old World Monkeys to Greater Anthropoids. But Primogenial Man has a relative articulation less than the Greater Anthropoids and standing between them and *Dryopithecus*. He is however nearest to the Recent Chimpanzee. Recent Man recedes still further from the Anthropoids much as the Gibbon has receded from its fossil predecessors. It would be not unreasonable to suggest that the Prot-simio-human—

TABLE LV. *Distal Articulation Ratio.*

	Group	Distal Articulation Ratio		
Lemuroids	*Tarsiidae* (2) ...	9·5		
	Indrisinae (8) ...	10·9		
	Lemurinae (18) ...	12·3		
	Lorisinae (6) ...	12·5		
	Galaginae (6) ...	12·8		
	Chiromyrdae (2) ...	12·85	Mean 11·81	
Cebidae	*Brachyurus* (2) ...	11·3		
	Pithecia (2) ...	11·75		
	Nyctipithecinae (8)	13·0		
	Ateles (4)	13·65		
	Hapalinae (16) ...	13·7		
	Cebus (6)	14·1		
	Mycetes (2) ...	15·1	Mean 13·80	
	Lagothrix (2) ...	17·8		
Simiadae	*Cercocebus* (4) ...	12·0		
	Semnopithecus (10)	12·9		
	Cercopithecus (8) ...	14·3		
	Cynocephalus (8) ...	14·9		
	Macacus (14) ...	15·1	Mean 13·84	
	Dryopithecus rhenanus (1)	12·3		
Simiinae	Gibbon (2)	11·75		
	Chimpanzee (2)	18·55	Mean 20·08	
	Orang (5)	19·5		
	Gorilla (7)	22·2		
	Pithecanthropus erectus (1) ...	16·0?		
Primogenial Man	Neanderthal Type (6)	16·5		
	Grimaldi Type (2)	16·1??		
	Cromagnon Type (5)	15·5		
	Homo aurignacensis (*Hauseri*) (1)	[15·1]		
Recent Man	17th century Londoners ♂ (73) ...	15·76*		
	„ „ ♀ (62) ...	15·29		

* Our Australian femora give: ♂ 16·15 (2), ♀ 16·4 (2), approaching in this more the Neanderthal Type.

the ancestor of the Greater Anthropoids and Man—had a distal articulation index of 16 or 17, *i.e.* was in this attribute chimpanzee-like in character.

It is, perhaps, worth noting that no individual genus now stands very close to the family means, although we recognise fully how the addition of another species might change any generic mean, so few are the individual species in each genus that we have been able to deal with. The nearest representatives of type are: the Lemurs in the Lemuroids, *Hapalinae* in the New World Monkeys, although *Cebus* is but slightly displaced, *Cercopithecus* in the Old World Monkeys, while the Chimpanzee is only representative of type in the Anthropoids provided we take the Gibbon into account, otherwise the centre is shifted to the Orang. The positions of *Tarsius*, the Aye-Aye and *Lagothrix* suggest specialised development rather than closeness to ancestral forms, if we assume that a family has spread out in a variety of directions from an ancestral form in order to cover special phases of environment, rather than developed in a single direction.

(*b*) *Distal Articulation Index.* The next index to come under consideration is the Distal Articulation Index, *i.e.* the ratio of the breadth of the distal articulation to the breadth of the distal epiphysis. It may be taken as a rough measure of the extent to which the distal epiphysis serves as a bearing surface. In Neanderthal Man it is a relatively small portion, in the *Indrisinae*, *Ateles*, *Cynocephalus* and the Orang a relatively large portion.

TABLE LVI. *Distal Articulation Index.*

	Group	Distal Articulation Index		Group	Distal Articulation Index
Lemuroids	*Lorisinae* (6) ...	80·65		*Dryopithecus rhenanus* (1)	85·9
	Chiromyrdae (2) ...	86·05			
	Tarsiidae (2) ...	88·45	Simiinae	Chimpanzee (2)	84·15
	Lemurinae (18) ...	90·0		Gibbon (2)	89·7
	Galaginae (6) ...	90·1		Gorilla (7)	90·2
	Indrisinae (8) ...	93·2 Mean 88·08		Orang (5)	93·3 Mean 89·34
Cebidae	*Brachyurus* (2) ...	87·9		*Pithecanthropus erectus* (1) ...	93·6?
	Nyctipithecinae (8)	88·6	Primogenial Man	Neanderthal Type (6)	79·4
	Hapalinae (16) ...	89·0		*Homo aurignacensis* (*Hauseri*) (1)	[85·3]
	Cebus (6)	89·0		Grimaldi Type (2)	85·6??
	Mycetes (2)	89·1		Cromagnon Type (5)	88·3
	Lagothrix (2) ...	90·7			
	Pithecia (2) ...	90·75 Mean 89·74	Recent Man	17th century Londoners ♂ (73) ...	89·57*
	Ateles (4)	92·9		,, ,, ♀ (62) ...	88·53
Simiadae	*Cercocebus* (4) ...	89·5			
	Macacus (14) ...	90·5			
	Cercopithecus (8) ...	90·6			
	Semnopithecus (10)	91·0			
	Cynocephalus (8) ...	93·2 Mean 90·96			

* Our Australian femora give: ♂ 91·3 (2), ♀ 92·95 (2), diverging therefore more than our Londoners from the Neanderthal Type.

Now this table is of interest because it indicates that the Distal Articulation Index has not changed more than a point since the Lemuroid stage. The Lesser Apes, both

Old World and New World, advanced perhaps two points, the Anthropoids fell back again a point and Recent Man is practically identical with the mean of the Anthropoids, 89, which is one point above the mean of the Lemuroids, or above *Tarsius* and one point less than the Lemurs. The singular constancy throughout the primates of this index is noteworthy. The only anomalous value is Man of the Neanderthal Type (79·4), which is only approached by the *Lorisinae*. We might be inclined to doubt it altogether did not the fossil Gibbon show a loss of four points on the Recent Gibbon, which suggests a possible loss of four points of the fossil Chimpanzee on the recent Chimpanzee and would bring us very nearly to 80 and the Neanderthal value for the Prot-simio-human. Even then this primate would find no parallel among recent primates except the *Lorisinae*.

The value for *Pithecanthropus* is a doubtful value and for a single bone, even so it is well within the human range (81·7—101·0) and much nearer to Recent Man than to the fossil Gibbon. Our values for Primogenial Man are undoubtedly singular, but they are admittedly precarious. Still they correspond to what we have several times had to note—an index considerably lower than the Anthropoid value rising to at least Recent Man value in Cromagnon Type femora, and thus marking a reversion to ape-like values. Thus Recent Man separates the Anthropoids from Primogenial Man—a not infrequent occurrence. The significant point which should be borne in mind is that Primogenial Man is differentiated from Recent Man in the same sense as the Chimpanzee and *Dryopithecus rhenanus* from the other Anthropoids. In the case of the distal index *Tarsius* supplies the type to the Lemuroids, *Mycetes* or *Cebus* to the *Cebidae*, *Cercopithecus* to the *Simiadae* and, what is unusual, the Gibbon to the Anthropoids.

(*c*) *Rotular Ratios.* We now pass to the relative size of the patellar height, and take in one table the Rotular Ratio and the Diaphysial Rotular Ratio.

Here it will be noted that there is a regression in both indices from the Lemuroids to the Lesser Apes, although it is more marked in the New World Monkeys. Between the *Simiadae* and the *Simiinae* there is very little difference, if the Gibbon be included, although there is a distinct rise (7·6 and 9·3), if we deal only with the Greater Anthropoids. Then with Primogenial Man we have the same peculiarities as in the case of the Distal Articulation Index, the index falls to a very low value and then rises almost to Recent Man values with Cromagnon Man. It is as if palaeolithic man had inherited the *absolute size* of patellar surface of some apelike ancestor placed upon a femur of much increased size. With Cromagnon Man the articular surface is increased in proportion to the size of the femur, and the rotular indices become almost those of Modern Man. If we may trust our values for *Homo aurignacensis* (*Hauseri*), that femur in the distal articulation is not modern, being nearer to Neanderthal than to Recent Man. *Dryopithecus rhenanus* is fairly close to the Recent Gibbon, and those who believe in a gibbonlike ancestry for Man and the Anthropoids may legitimately associate Recent Man with the Gibbon in this character, but if this be done they must clearly place Primogenial Man on a different line of descent, for if Recent Man came through him, Fossil Man and Fossil Gibbon diverge from rather than approach each other.

TABLE LVII. *Rotular Ratio and Diaphysial Rotular Ratio.*

	Group	Rotular Ratio	Diaphysial Rotular Ratio
Lemuroids	*Chiromyrdae* (2)	5·45	7·3
	Indrisinae (8) ...	6·8	7·6
	Lorisinae (6) ...	7·2	8·4
	Galaginae (6) ...	9·05	10·8
	Tarsiidae (2) ...	9·2 Mean 7·93	10·6 Mean 9·37
	Lemurinae (18) ...	9·9	11·5
Cebidae	*Pithecia* (2) ...	5·15	5·8
	Lagothrix (2) ...	5·7	6·8
	Ateles (4) ...	5·75	6·1
	Cebus (6) ...	6·0	6·9
	Brachyurus (2) ...	6·3 Mean 6·08	7·1 Mean 6·94
	Nyctipithecinae (8)	6·3	7·2
	Mycetes (2) ...	6·25	7·3
	Hapalinae (16) ...	7·2	8·3
Simiadae	*Semnopithecus* (10)	6·7	7·7
	Cynocephalus (8)	6·75	7·8
	Macacus (14) ...	7·0	8·1
	Cercocebus (4) ...	7·25 Mean 7·02	8·3 Mean 8·07
	Cercopithecus (8)	7·4	8·45

	Group	Rotular Ratio	Diaphysial Rotular Ratio
	Dryopithecus rhenanus (1) ...	5·9	6·6
Simiinae	Gibbon (2)	5·7 Mean 7·12	6·45 Mean 8·61
	Chimpanzee (2)	7·2	8·6
	Gorilla (7)	7·3	8·7
	Orang (5)	8·3	10·7
	Pithecanthropus erectus (1) ...	5·3	6·1
Primogenial Man	Neanderthal Type (6)	3·95	4·7
	Homo aurignacensis (*Hauseri*) (1)	[4·6]	[5·2]
	Cromagnon Type (5)	5·4	6·3
	Grimaldi Type (2)	6·3??	7·1??
Recent Man	17th century Londoners ♂ (73)	5·73	6·75*
	" " ♀ (62)	5·62	6·61

* Our Australian femora give Rotular Ratio: ♂ 5·9 (2), ♀ 5·7 (2) and Diaphysial Rotular Ratio: ♂ 7·0 (2), ♀ 6·85 (2), diverging more than our Londoners from the Neanderthal Type.

The *Lorisinae* for this character are nearest to type in the Lemuroids, *Cebus* in the *Cebidae*, *Macacus* in the *Simiadae* and the Chimpanzee in the *Simiinae*.

(*d*) *Rotular Index.* We now turn to our last index of the distal articulation, *i.e.* the Rotular Index, which measures in a rough way the ratio of articular surface height to breadth. The following table gives our data.

Now this table expresses numerically the fact obvious on the inspection of the femora that from *Tarsius* to Neanderthal Man there has been decrease of the patellar height relative to increase of the distal articular breadth. If as we think probable the long tongued patellar articular surface be associated with power of spring (cf. femora of cats, rabbits, hares, etc.[1]), then a big factor in the history of the evolution of the primate femur is the replacement of the power of springing by power of upright gait. Among the Lemuroids *Tarsius* and the Lemurs have the highest index and on this assumption the highest power of spring; the lowest indices are those of the Aye-Aye and *Lorisinae*, but these are far above the average of the *Cebidae*. In that family

[1] The following table gives the Rotular Index for certain mammals:

Wild Rabbit	78·2
American Agouti	67·7
Domestic Cat	64·9
Lion	48·1
Six-banded Armadillo	40·9

Lagothrix and unexpectedly *Ateles*[1] stand at the bottom while the *Hapalinae* and *Brachyurus*[2] are the most powerful in spring. Among the *Simiadae Macacus* and *Cynocephalus* should be on our hypothesis those most upright in gait, while *Cercopithecus* and *Cercocebus* retain a power of spring of almost a Lemuroid character. *Dryopithecus rhenanus* stands close to the Recent Gibbon which with the Orang are the most agile of the *Simiinae*, while Gorilla and Chimpanzee are the more capable of vertical gait. With Neanderthal Man the index and hypothetically the power of spring reaches its minimum and then begins to ascend through Cromagnon and possibly Grimaldi Types till it reaches again a value in Recent Man little less than

TABLE LVIII. *Rotular Index.*

	Group	Rotular Index		
Lemuroids	*Chiromyrdae* (2) ...	49·7	Mean 69·26	
	Lorisinae (6) ...	57·2		
	Indrisinae (8) ...	62·3		
	Galaginae (6) ...	69·4		
	Lemurinae (18) ...	80·2		
	Tarsiidae (2) ...	96·75		
Cebidae	*Lagothrix* (2) ...	32·05	Mean 45·28	
	Ateles (4)	38·5		
	Cebus (6)	42·7		
	Pithecia (2) ...	43·95		
	Mycetes (2) ...	47·45		
	Nyctipithecinae (8)	48·9		
	Hapalinae (16) ...	53·0		
	Brachyurus (2) ...	55·7		
Simiadae	*Macacus* (14) ...	45·1	Mean 51·00	
	Cynocephalus (8) ...	46·7		
	Semnopithecus (10)	51·0		
	Cercopithecus (8) ...	51·8		
	Cercocebus (4) ...	60·4		

	Group	Rotular Index	
	Dryopithecus rhenanus (1)	47·6	
Simiinae	Gorilla (7)	32·7	Mean 38·15
	Chimpanzee (2)	38·75	
	Orang (5)	43·0	
	Gibbon (2)	48·3	
	Pithecanthropus erectus (1) ...	32·9?	
Primogenial Man	Neanderthal Type (6)	24·0	
	Homo aurignacensis (*Hauseri*) (1)	30·5	
	Cromagnon Type (5)	32·4	
	Grimaldi Type (2)	34·7??	
Recent Man	17th century Londoners ♂ (73) ...	36·75*	
	„ „ ♀ (62) ...	36·74	

* Our Australians give: ♂ 36·75 (2), ♀ 34·65 (2), and diverge as much as the Londoners from the Neanderthal Type.

that of *Ateles* and the Chimpanzee. If our suggestion be a valid one Recent Man, while retaining his uprightness of gait—the breadth of his distal articulation is as great as that of Neanderthal Man—has recovered something of the ape power of spring—his patellar height has increased beyond that of Neanderthal Man. We have in fact further evidence of that reversion of Recent Man to a more apelike character than that of Primogenial Man, who so to speak overshot the mark.

If we can rely on the value given for *Pithecanthropus erectus*, it is widely remote from either Recent or Fossil Gibbon. The owner of the Trinil femur had less power

[1] *Ateles* so generally runs parallel to the Gibbon that the result is unexpected. It would be interesting to know the exact difference in mode of progression between *Ateles* and the Gibbon. We cannot account for the position of *Ateles* by supposing a considerable patellar height, but a great breadth of distal articulation; both are in fact mediocre.

[2] The position of *Brachyurus* in all these tables must be taken as open to question, for our specimen was a young one.

of spring than Recent Man's average, although the doubtful value of his index falls within the human range (28 to 43). We may conclude this discussion of the table by noting that the *Galaginae* are nearest to type in the Lemuroids; that the type lies between *Pithecia* and *Mycetes*—or better between *Cebus* and *Nyctipithecinae*, for the former are represented only by two femora apiece—for the *Cebidae*. *Semnopithecus* is exactly type for the *Simiadae* for this character, while the Chimpanzee is again type for the Greater Anthropoids.

C. *General Points as to Distal Articulation.* We may now draw attention to some general points bearing on the seven characters of the distal articulation treated in this section. In all but one case, that of the absolute patellar height[1], both Old and New World Monkeys differ from the Lemuroids in the *same* direction. In view of this it is very difficult to accept such a pedigree as that of Haeckel's which assumes the *Cebidae* to have parted from the main line of descent before but the *Simiadae* later than the Lemuroid stage. Putting aside absolute size in which the *Simiadae* have made much greater progress than the *Cebidae*, out of the five indices the *Simiadae* in two, both those for distal articulation, have gone further from the Lemuroids than the *Cebidae*, but in both these cases the differences are so slight that we might be content to say that in pure distal articulation indices Old and New World Monkeys agree. On the other hand for the three rotular indices the *Simiadae* are sensibly more remote than the *Cebidae* from the Lemuroids. It would thus seem legitimate to argue, *as far as the distal articulation of the femur is concerned*, that both *Cebidae* and *Simiadae* came off from a Lemuroid ancestry and fixed the distal articulation ratio and index before separation; that after separation the *Simiadae* retained or developed higher rotular indices than the *Cebidae*, *i.e.* may have had a tendency to revert towards the Lemuroids; that this manifests itself to the full in the Greater Anthropoids, which are practically lemuroid in the rotular ratios, but in the rotular index—that which makes in our opinion for upright gait—the Greater Anthropoids have carried out the progression started in the *Cebidae*, the progression which leads to Man, while the Gibbon, in both fossil and recent forms, has scarcely bettered the position of the *Simiadae*, and remained essentially a springing animal.

With regard to type forms for the articulation of the distal epiphysis our results seem to indicate that the *Lorisinae*[2] form the type for the Lemuroids with three firsts and one second out of seven characters; that *Cebus* is the type for the *Cebidae* with four firsts and one second; that *Macacus* with three firsts and one second is type for the *Simiadae*; while the Chimpanzee with four firsts and one second is type for the Greater Anthropoids.

We trust that this slight investigation of the distal articular surface will indicate how much of interest would arise from a fuller discussion of this surface not only for the primates but for the mammals as well.

[1] Even in this case all we can say is that the *Cebidae* do not differ sensibly in patellar height from the Lemuroids.

[2] The Lemur is only closest to type in one and second in two characters; a position equalled by *Tarsius*.

(x) *Concluding Remarks on the Distal Epiphysis.*

The accompanying table gives our reconstruction of the hypothetical Protsimio-human. We note again how close in many respects are the indices to those of Recent Man, the values of which were not considered in our determination. This seems to us to emphasise the point that many of the human femoral characters are more primitive than has been anticipated and we hold that the Greater Anthropoids have diverged from a type which was not without many human characters. At the same time that type indicially is usually intermediate between Recent Man and Recent Chimpanzee, while Recent Gibbon lies as a rule outside that range. In those characters in which Man and Chimpanzee are widely divergent from the Gibbon our Protsimio-human will be found to follow the former and not the latter, in other words its femur is troglodytic not hylobatic. Thus the distal epiphysis confirms the surmises we have made from the indices of the shaft and the proximal epiphysis.

TABLE LIX. *Characters of the Distal Epiphysis of the Hypothetical Protsimio-human.*

Character	Recent Gibbon	Protsimio-human	Recent Chimpanzee	Recent Man
Bicondylar Width	25·25	62·0	69·3	74·88
Max. Length Ext. Condyle ...	18·0	47·7	43·4	59·28
Max. Length Int. Condyle ...	19·15	47·7	51·5	58·81
Oblique Length Ext. Condyle ...	17·45	46·3	41·45	58·46
Oblique Length Int. Condyle ...	17·6	43·9	45·45	54·20
Ext. Cond. Hor. Band-radius ...	7·45	18·0	20·1	17·85
Ext. Cond. Vert. Band-radius ...	7·25	17·8	19·55	19·65
Height, Patellar Surface ...	10·95	19·5	22·6	24·34
Breadth, Distal Articulation ...	22·6	52·1	58·3	66·23
Condylar Index	74·4	77·0	62·65	79·0
Condylar Lengths Index ...	94·1	100·0	84·2	100·57
Bicondylar Ratio	13·05	19·1	22·0	17·54
Band-radial Index ...	97·8	99·0	97·25	111·36
Condylar Troch. Index	9·4	15·0	13·95	14·57
Distal Articulation Ratio ...	11·75	16·0	18·55	15·52
Distal Articulation Index ...	89·7	84·0	84·15	89·05
Rotular Ratio	5·7	6·0	7·2	5·67
Rotular Index	48·3	37·4	38·75	36·75
Diaphysial Rotular Ratio ...	6·45	7·14	8·6	6·68

We fear the reader will consider our discussion of the distal epiphysis singularly incomplete and we frankly admit the truth of the criticism; but this incompleteness arises, however, largely from the fact already referred to, namely that comparative human material is almost entirely wanting, and in view of this our aim has been to suggest the interesting problems which are associated with the femoral part of the knee-joint rather than to assert dogmatic conclusions. In the intervals of more engrossing war work, it has been easier to work on the femora of monkeys and apes, than to deal *de novo* with long series of human femora, which are only to be found in

continental, especially French Museums. But this very extension of our work to the lower primates has opened up broader and more general problems than could arise from interracial data in the case of Man, and we hope that this fact may to some extent compensate the anthropologist for the absence of comparative human material in this section. That absence indeed may suggest questions to be answered if he has the osteometric material at his disposal, while to those anthropologists, who are living in touch with the primitive races of to-day, we would appeal begging them to remember that this monograph has striven to demonstrate that crania are not the only material which it is valuable to collect and forward to the museums and laboratories of this country.

(xi) *An Examination of the Dwarf Femur.*

We have noted in the course of our discussion on the femur of Recent Man that we meet with simiine and even lemuroid reversions in certain of the anomalies of the human femur; we have further noted that these anomalies not infrequently appear to be associated with pathological femoral conditions (see our p. 107 and elsewhere). On our hypothesis the prot-simio-human femur was a short robust femur of a troglodyte character, 40 % longer than that of the Recent Chimpanzee, it is true, but 20 % shorter than that of Recent Man; it would have accordingly much the size of the femur of dwarf Recent Man. It appeared just worth the while to inquire whether the femur of the human dwarf has any characters, which can be looked upon as at all reversions to our prot-simio-human femur. We devote this section to certain comparative measurements intended to throw light on this point.

It is well known that human dwarfs may be divided into three broad classes: namely (i) the Racial Dwarfs or true Pygmies, and the Pathological Dwarfs divided into the two main groups, (ii) Ateleiotic Dwarfs and (iii) Achondroplasic Dwarfs[1]. Of the racial dwarfs we have been able to measure the femora of two Bushmen, and an Andaman from the Museum of the Royal College of Surgeons. We have not studied the Akka femur, owing to the necessity during the past few years of working on material which could be at once picked up and dealt with in the brief intervals of other work. For the pathological dwarfs we have both femora of a dwarf from Ancient Egypt. This dwarf appears to us to be ateleiotic from the femora although the skull is of large size. A notable feature is the great difference with regard to quite a number of characters of the right and left femora of this dwarf[2]. Lastly we have an excellent example of true achondroplasia in the femur of a dwarf from Khartoum. The skeletons of these last two dwarfs are also in the Museum of the Royal College of Surgeons. In the following table we place the measurements of these dwarfs against those of our Prot-simio-human and of two very primitive types of femora, namely: (*a*) the mean of two Australian aboriginal males

[1] See the *Treasury of Human Inheritance*, Vol. I, pp. 355 *et seq.* Cambridge University Press.

[2] From the pathological side this skeleton has been very fully discussed by Dr Douglas E. Derry: "A case of Hydrocephalus in an Egyptian of the Roman Period," *Journal of Anatomy and Physiology*, Vol. XLVII, pp. 436—458, London, 1913. He notes hemiplegia and partial paralysis of left side, but does not emphasise the dwarfism.

TABLE LX. *Comparison of Prot-simio-human Femur with those of Racial and Pathological Dwarfs and with Primitive Femora.*

	Characters	Absolute Values									
		Australian Aboriginal (2) ♂	"Primitive" Human Femur (1) ♂ L.	Prot-simio-human	Chimpanzee (2)	Achondroplasic Dwarf L.	Ateleiotic Dwarf R.	Ateleiotic Dwarf L.	Racial Dwarfs		
									Bushman ♀ A (L.)	Bushman ♀ B (R.)	Andaman R.
Major Lengths	Maximum Length	451·45	456·5	325	314·55	263·5	383·8	380·0	437·0	384·0	367·5
	Trochanteric Length	425·0	445 0	318	311·0	263·5	355·1	358·8	414·5	371·2	339·5
	Maximum Troch. Length	438·7	452·0	322·5	313·35	267·0	365·9	362·0	426·7	372·8	347·5
	Oblique Length	444·3	455·5	322·5	311·85	262·0	378·2	379·5	428·0	382·0	363·5
	Troch. Oblique Length	417·3	445·0	318	311·85	263·0	352·1	360·0	404·7	370·0	338·5
	Capito-trochlear Length	431·15	441·5	301	303·65	241·2	362·8	361·2	417·5	368·7	349·1
	Diaphysial Length	381·5	401·0	273	261·8	197·0?*	317·5	323·5	376 0	332·5	304·2
	Length of Shaft	384·6	396·0	271·5	257·35	200·6	328·9	324·0	375·9	332·7	307·9
Bust	Vert. Diam. of Head	49·05	46·5	36·0	36·15	44·2	43·5	44·5?	41·6	35·4	35·6
	Horiz. Diam. of Head	47·45	45·7	35·8	36·2	44·9	42·5	40·8	40·9	35·4	35·6
	Min. Horiz. Diam. of Neck	23·9	23·9	19·7	17·55	20·3	23·4	21·6	22·2	20·0	19·3
	Min. Vert. Diam. of Neck	36·83	34·2	25·2	22·7	20·4	31·5	31·5	30·7	25·4	23·2
	Capito-collar Length	81·1	80·0	51·5	62·4	58·9	48·8	50·0	58·3	55·3	56·7
	Length of Neck	56·6	56·75	33·5	44·3	36·8	27·05	27·75	37·5	37·6	38·9
Shaft	Proximal Breadth	104·8	102·3	70·0	68·5	75 5	85·4	78·7	83·7	72·6	76·4
	Platymeric A. P. Diam.	25·8	27·5	22·7	21·95	21·3	25·0	19·5	23·6	18·4	19·4
	Platymeric Trans. Diam.	32·9	36·4	25·8	26·2	28·2	26·4	27·3	29·5	24·2	23·4
	Pilastric A. P. Diam.	29·85	35·2	22·8	21·4	24·0	27·3	26·4	32·6	21·0	24·6
	Pilastric Trans. Diam.	27·5	30·1	23·25	25·85	25·2	22·1	17·2!	25·0	22·2	19·7
	Popliteal Length	121·75	97·5	102·3?	123·15?	79 2?	71·4	105·6	89·1	100·4	111·7
	Popliteal Width	41·35	43·6	31·0	34·35	34·1	38·1	32·1	37·1	32·3	31·9
	Poplit. Direct A. P. Diam.	32·5	31·6	21·7	23·45	23·8	27·9	21·2	28·8	21·5	21·0
	Poplit. Oblique A. P. Diam.	32·75	34·1	22·4	25·15	24·1	28·3	23·5	31·4	23·0	25·0
	Diaphysial Chord	261·85	282·7	182·1	179·8	134·2	211·9	209·2	242·2	231·6	207·3
	Diaphysial Subtense	8·35	9·3	5·6	5·25	± 1·2†	4·5	5·2	6·0	8·2	7·7
	Prox. Segm. Diaph. Chord	100·15	102·7	89·2	77·2	?	108·1	95·5	105·1	91·2	83·2
Condyles	Bicondylar Width	79·85	84·8	62·0	69·3	76·4	74·6	74·0	70·9	64·5	63·8
	Max. Length Ext. Condyle	65·95	64·6	47·7	43·4	60·5	59·7	58·9	54·2?	52·9	53·2
	Max. Length Int. Condyle	66·3	67·8	47·7	51·5	62·9	52·3	51·8	55·3	51·6	52·6
	Oblique Length Ext. Condyle	65·35	63·4	46·3	41·45	56·7	57·6	55·7	52·8	52·4	52·6
	Oblique Length Int. Condyle	60·85	59·5	43·9	45·45	53·9	48·9	48·9	52·0	48·5	50·1
	Ext. Condylar Hor. Band-radius	19·4	21·5	18·0	20·1	20·5	17·4	18·2?	19·1?	18·0	17·7
	Ext. Condylar Vert. Band-radius	21·6	21·8	17·8	19·55	17·5	16·7	16·9?	16·9?	15·9	18·0
	Height, Patellar Surface	26·65	26·2	19·5	22·6	27·7	23·7	22·2	24·3	21·6	18·5
	Breadth, Distal Articulation	72·9	77·1	52·1	58·3	68·8	67·3	67·8	64·2?	61·2	62·3
Angles	Mid-trochlear Angle	9°·15	10°·0	8°·5	9°·0	11°·3	5°·5	6°·2	5°·7	6°·8	6°·8
	Angle at Centre of Head	50°·7	55°·0	51°·0	37°·75	42°·0	43°·1	40°·9	42°·1	46°·1	39°·2
	Collar Angle	120°·15	115°·0	120°·5	133°·25	126°·7	131°·4	132°·9	132°·2	127°·1	134°·0
	Torsion of Shaft	6°·1	20°·0	15°·0	10° 5	21°·5	8°·5	101°·5!!	38°·5	39°·5	39°·0
	Torsional Angle	− 5°·25	9°·6	6°·0	3°·75	1°·0	− 22°·0	+ 54°·5!	− 6°·5	12°·7	15°·7
	Retorsional Angle	11°·35	10°·4	9°·0	6°·75	20° 5	30°·5	47°·0	45°·0	26°·8	23°·3
	Obliquity of Shaft	15°·15	7°·0	3°·0	− 0°·1	6°·5	8°·5	4°·0?	14°·5	9° 0	8°·5
	Pseudo-obliquity	10°·15	3°·8	7°·1	7°·5	6°·1	9°·8	2°·9	11°·6	5°·8	8°·5

* There is a broad and fairly deep groove between patellar surface and shaft.

† The curvature of anterior face of shaft exhibits a point of inflexion, *i.e.* is double-bellied.

	Characters	Indicial Values									
		Australian Aboriginal (2) ♂	"Primitive" Human Femur (1) ♂ L.	Prot-simio-human	Chimpanzee (2)	Achondro-plasic Dwarf L.	Ateleiotic Dwarf R.	Ateleiotic Dwarf L.	Racial Dwarfs		
									Bushman ♀ ? A (L.)	Bushman ♀ B (R.)	Andaman R.
General Indices	Oblique Direct Lengths Index ...	98·84	99·78	99·23	99·1	99·43	98·54	99·87	97·94	99·48	98·91
	Oblique Direct Troch. Lengths Index	97·89	100·00	100·00	100·3	99·81	99·15	100·33	97·64	99·68	99·71
	Proximal Breadth Ratio	24·66	22·99	22·0	22·15	28·65	24·05	21·93	20·19	19·56	22·50
	Distal Breadth Ratio	18·79	19·06	19·5	22·25	28·99	21·01	20 62	17·10	17·38	18·79
	Pithecoid Index	93·9	97·7	98·6	100·0	100·4	93·1	94·9	94·6	96·9	93·1
	Robusticity of Femur	12·91	14·34	14·3	15·15	18·78	13·06	11·49	13·46	11·31	12·19
Bust Indices	Robusticity of Head	21·7	20·2	22·3	23·2	34·0	22·7	22·5 ?	19·3	18·5	19·6
	Ellipticity of Head	96·8	98·3	99·4	100·15	101·6	97·7	91·7	98·3	100·0	100·0
	Ellipticity of Neck	65·8	69·9	78·0	77·3	99·5	74·3	68·6	72·3	78·7	83·2
	Secondary Index of Neck	50·4	52·3	55·0	48·5	45·2	55·1	52·9	54·3	56·5	54·2
	Lemotic Index	12·75	12·5	10·4	14·2	14·0	7·2	7·3	8·8	9·8	10·1
	Head Bust Ratio	60·6	58·1	69·9	57·95	75·0	89·1	89·0 ?	71·3	64·0	62·8
	Primary Bust Ratio	17·95	17·5	15·8	19·85	22·4	12·7	13 2	13·3	14·4	15·4
	Secondary Bust Ratio	18·25	17·6	16·0	20·05	22·5	12·9	13·2	13·6	14·5	15·6
	Bust Shaft Index	21·1	20·2	19·0	24·25	29·4	14·8	15·4	15·5	16·6	18·4
	Capital Ratio	10·85	10·2	11·1	11·5	16·8	11·3	11·7 ?	9·5	9·2	9·7
	Capito-bicondylar Ratio	61·4	54·3	58·1	52·2	57·8	58·3	60·1 ?	58·7	54·9	55·8
	Epiphysial Ratio	101·65	94·3	83·1	90·0	77·1	65·4	67·6	82·2	85·7	88·9
Shaft Indices	Platymeric Index	78·45	75·6	88·0	83·8	75·5	94·7	71·4	80·0	76·0	82·9
	Pilastric Index	108·65	116·9	98·0	82·8	95·2	123·5	153·5 !	130·4	94·6	124·9
	Popliteal Index	78·6	72·5	70·0	68·25	69·8	73·2	66·0	77·6	66·6	65·8
	Index of Popliteal Skewness ...	99·25	92·7	96·9	93·35	98·8	98·6	90·2	91·7	93·5	84·0
	Popliteal Pyramidal Index ...	34·05	44·7	30·3 ?	27·95 ?	43·1 ?	53·4	30·4	41·6	32·2	28·6
	Soffit Index	51·75	51·4	50·0	49·55	44·6	51·1	43·4	52·3	50·1	50·0
	Index of Gracility (Upper) ...	83·6	82·7	90·0	98·7	89·4	83·7	63·0	84·7	91·7	84·2
	Index of Gracility (Lower) ...	66·55	69·0	75·0	75·25	73·9	58·0	53·6	67·4	68·7	61·7
	Index of Trans. Slenderness ...	7·15	7·6	8·6	10·05	12·6	6·7	5·3	6·7	6·7	6·4
	Index of Sagit. Slenderness ...	7·8	9·1	8·4	8·3	12·0	8·3	8·1	8·7	6·3	8·0
	Index of Prox. Taper	86·45	78·1	99·6	102·35	88·8	91·6	73·9	72·4	87·6	78·9
	Index of Distal Taper	108·9	89·8	95·2	109·55	99·2	102·2	80·3	88·3	102·4	85·4
	Popliteal Shaft Index	31·65	24·6	37·7	47·85	39·5 ?	21·7	32·6	23·7	30·2	36·3
	Primary Index of Bowing	3·15	3·3	3·2	2·95	[± 0·9]*	2·1	2·5	2·5	3·5	3·7
	Secondary Index of Bowing ...	38·3	36·3	49·0	42·95	?	51·0	45·7	43·4	39·4	40·1
Condylar Indices	Condylar Index	82·6	76·2	77·0	62·65	79·2	80·0	79·6	76·4 ?	82·0	83·4
	Condylar Lengths Index	99·5	95·3	100·0	84·2	96·2	114·1	113·7	98·0 ?	102·5	101·1
	Bicondylar Ratio	17·65	18·6	19·1	22·0	29·0	19·4	19·5	16·2	16·8	17·4
	Band-radial Index	111·4	101·4	99·0	97·25	85·4	96·0	92·9 ?	88·5 ?	88·3	101·7
	Condylar Troch. Index	15·5	14·5	15·0	13·95	23·0	16·8	16·4	13·1 ?	14·3	15·7
	Distal Articulation Ratio	16·15	16·9	16·0	18·55	26·1	17·5	17·8	14·7 ?	15·9	16·9
	Distal Articulation Index	91·3	90·9	84·0	84·15	90·1	90·2	91·6	90·5	94·9	97·6
	Rotular Ratio	5·9	5·7	6·0	7·2	10·5	6·2	5·8	5·6	5·6	5·0
	Rotular Index	36·75	34·0	37·4	38·75	40 3	35·2	32·7	37·9 ?	35·3	29·7
	Diaphysial Rotular Ratio	7·0	6·5	7·15	8·6	14·1 ?	7·5	6·9	6·5	6·5	6·1

* See second footnote on preceding page.

in our possession and (*b*) a singularly primitive human femur, obviously of considerable antiquity, of which we have no history, also in our Laboratory.

(*a*) *Angles.* Now there is little to be learnt from absolute size because our fundamental length for the Prot-simio-human is very arbitrary and might easily be 25 mm. in excess or defect. On the other hand the absolute values of the femoral angles are of importance and we see that the fundamental triangle for the Prot-simio-human differs not only from that of Recent Man (angles 7°·8, 41°·5, 130°·7), but from those of both pathological and racial dwarfs, which are singularly close to that of Recent Man as typified by our Londoners. It is obviously closer to the primitive type of human femur as exhibited in the first two columns.

Again the torsion of the shaft is higher in the racial dwarfs (39°·0) than in Recent Man (25°·0), to which latter value the achondroplasic femur (21°·5) approaches. The Prot-simio-human femur belongs again to the relatively low torsion of the shaft group represented by the primitive femora of the first two columns. Little can be said of the ateleiotic dwarf unless we hide the truth under a mean! His right femur exhibits low torsion of the shaft (8°·5), similar in intensity to the Australians (6°·1), but his left femur has a higher grade of shaft torsion (101°·5) than we have ever before encountered. This is only saying that this dwarf's left femur is certainly deformed, as may also be observed in the pilastric diameters and index. In the case of retorsion, both kinds of dwarfs exhibit a high degree of it; the primitive femora and the Prot-simio-human a low degree of it. Lastly for the torsion of the femur in the ordinary sense the Prot-simio-human agrees with the primitive femora in having a low degree of it. The Andaman and one Bushman have a moderate amount of torsion similar to that of Recent Man (about 14°·0). The other Bushman has a small negative torsion, while the achondroplasic dwarf has a negligible torsion and the ateleiotic dwarf shows in the two members opposite exaggerations of torsion. Thus as in so many racial problems little is to be learnt from the femoral torsion proper. In the case of the obliquity the racial dwarfs give a mean of 10°·7 not very different from that of our Londoners (10°·4). The pathological dwarfs show a lower degree of obliquity (about 6°·3), while the Prot-simio-human has but a slight degree of obliquity. We should have anticipated only a small amount of obliquity in the "primitive race" femora—as in primogenial man; but this is certainly not the case with the Australians. Thus as far as it goes in this character the pathological dwarfs come somewhat nearer to the Prot-simio-human. For the whole series of angles, however, it is not possible to say that either pathological or racial dwarfs are more Prot-simio-human in character than non-dwarf primitive races.

(*b*) *General Indices.* With regard to the indices we find among the general indices that little can be learnt from the Oblique Direct Lengths Indices, whether for the capital or trochanteric lengths. Thus, in the case of the former, the primitive race femora have a value 99·3, the same as that of our Londoners and both in excess of the racial dwarfs, 98·8. The achondroplasic and ateleiotic femora might both be variations from that of Recent Man, and the same may equally be said of the Prot-

simio-human femur. More significant results flow from the robusticity of the femur. Here we have:

Achondroplasic Dwarf ...	18·8	Advanced Races ...	12·7
Prot-simio-human ...	14·3	Racial Dwarfs	12·3
Primitive Races... ...	13·6	Ateleiotic Dwarf ...	12·3

It is clear that the Prot-simio-human is separated by Recent Man from both ateleiotic and racial dwarfs, and that it is impossible to consider the exaggerated robusticity of achondroplasia as a reversion to a simian ancestry.

The Pithecoid Index gives us the following result:

Achondroplasic Dwarf ...	100·4	Advanced Races ...	95·2
Prot-simio-human ...	98·6	Racial Dwarfs	94·9
Primitive Races ...	95·8	Ateleiotic Dwarf ...	94·0

Thus the Racial and Ateleiotic Dwarfs are further removed from the Prot-simio-human than either group of Recent Man. The Achondroplasic Dwarf is, however, more simian than the Prot-simio-human for this character. We may not be able accurately to describe this fact as a reversion of the achondroplasic femur to the Prot-simio-human type, but it is certainly one among several features in which the achondroplasic bone is more simian not only than Recent Man, but than the Prot-simio-human itself.

For the Proximal and Distal Breadth Ratios we have:

	Proximal Breadth Ratio		Distal Breadth Ratio
Achondroplasic Dwarf ...	28·7	Achondroplasic Dwarf ...	29·0
Primitive Races	23·8	Ateleiotic Dwarf	20·8
Ateleiotic Dwarf	23·0	Prot-simio-human	19·5
Advanced Races	22·1	Primitive Races	18·9
Prot-simio-human	22·0	Advanced Races	18·5
Racial Dwarfs	21·1	Racial Dwarfs	17·8

In both cases the advanced races are nearer to the Prot-simio-human than any type of dwarf. It is not possible therefore to speak of the relative size of the epiphyses as a case in which any type of dwarf shows a reversion from normal man to a Prot-simio-human ancestor.

Accordingly the General Indices of the femur give no systematic support to the hypothesis that the dwarf is a reversion to or a survival of a distant ancestral form.

We may now consider the indices of the three chief portions of the femur.

(*c*) *Indices of the Shaft.* First, those of the shaft. We have summarised the results in Table LXI.

Now in analysing this summary we may dismiss at once any index where the Prot-simio-human lies between or on the borders of the range of values given for Recent Man, for it is clearly not possible in such a case to speak of reversion. Also, if an index for the dwarfs lies in this range it may again be dismissed from our consideration.

On the first ground we need not concern ourselves with the Popliteal Index, Index of Popliteal Skewness, Soffit Index, Index of Sagittal Slenderness, or the Primary Index of Bowing.

Now let us consider the Racial Dwarfs. The values of the Platymeric, Popliteal Pyramidal, Popliteal Shaft Indices and that of Proximal Gracility lie between those of Recent Man. The values of the Pilastric Index and the Indices of Distal Gracility, Transverse Slenderness and Proximal Taper lie outside the range for Recent Man, *but on the* other side of that range to the Prot-simio-human. This leaves only two out of the 15 indices of the shaft considered in which we could even suggest reversion. Of these the value of the Secondary Index of Bowing is four times closer to that of advanced man than to that of the Prot-simio-human. In the remaining fifteenth index the racial dwarf has so far overshot the mark that the Prot-simio-human is four times closer to the femur of the advanced races than to that of the Racial Dwarf. It will be seen that the shaft gives no evidence whatever that the Racial Dwarf is in any way a reversion or a relic of a Prot-simio-human ancestor. As far as the shaft is concerned we find no suggestion that man has ascended from a Prot-simio-human stage through a racial dwarf phase.

TABLE LXI. *Indices of the Shaft.*

Indices	Recent Man		Prot-simio-human	Dwarfs		
	Primitive	Advanced		Racial	Ateleiotic	Achondro-plasic
Platymeric Index	77·0	84·0	88·0	79·6	83·0	75·5
Pilastric Index	112·8	103·0	98·0	116·6	138·5	95·2
Popliteal Index	75·6	69·4	70·0	70·0	69·6	69·8
Index of Popliteal Skewness ...	96·0	90·8	96·9	89·7	94·4	98·8
Popliteal Pyramidal Index ...	39·4	32·9	30·3	34·1	41·9	43·1?
Soffit Index	51·6	50·4	50·0	50·8	47·3	44·6
Index Proximal Gracility ...	83·2	88·7	90·0	86·9	73·4	89·4
Index Distal Gracility ...	67·8	70·9	75·0	65·9	55·8	73·9
Index Trans. Slenderness ...	7·4	7·4	8·6	6·6	6 0	12·6
Index Sagittal Slenderness ...	8·4	7·5	8·4	7·7	8·2	12·0
Index of Proximal Taper ...	82·3	92·0	99·6	79·6	82·7	88·8
Index of Distal Taper ...	99·3	96·0	95·2	92·0	91·3	99·2
Popliteal Shaft Index ...	28·1	32·2	37·7	28·8	26·2	39·5?
Primary Index of Bowing ...	3·2	2·5	3·2	3·2	2·3	± 0·9
Secondary Index of Bowing ..	37·3	39·0	49·0	41·0	48·4	?

We next turn to the Ateleiotic Dwarf. The following indices lie in the Recent Man range: Platymeric Index and Index of Proximal Taper. The following indices lie outside the Recent Man range but on the opposite side to the Prot-simio-human, namely, the Pilastric, the Popliteal Pyramidal, and the Popliteal Shaft Index, together with the Indices of Proximal and Distal Gracility and of Transverse Slenderness. We are thus again reduced to the Index of Distal Taper and the Secondary Index of Bowing. Now, the Index of Distal Taper is for our ateleiotic dwarf: R. 102·2 and L. 80·3. It is impossible to consider either of these values as a reversion to a Prot-simio-human value of 95·2! We are thrown back, therefore, on a single index, that of

secondary bowing, as the sole suggestion of reversion. We may, therefore, certainly dismiss this type of dwarf from our consideration as a possible reversion.

We now turn to the other pathological dwarf, the achondroplasic. Here there are only 14 indices to be considered[1]; those of Proximal and Distal Taper lie in the Recent Man range; the Platymeric and Popliteal Pyramidal Indices lie outside that range, but on the opposite side of it to the Prot-simio-human value. There remain five indices for consideration. In the case of the Index of Proximal Gracility, the prot-simio-human value is 1·3 points (90·0) from the advanced race value (88·7) and the achondroplasic value as nearly as possible is midway between the two (89·4). No stress can therefore be laid on this as a possible case of reversion. The Index of Transverse Slenderness is so exaggerated in the case of the achondroplasic femur, that the value of this index for the Prot-simio-human is three times at least nearer to that of the advanced races. It seems again impossible to suggest that this is reversion! On the other hand, if we take the Pilastric and the Popliteal Shaft Indices, together with the Index of Distal Gracility, there is a distinct approximation in these features to a more simian form. The pilastric transverse, as in most apes, is greater than the pilastric antero-posterior diameter, the distal portions of mesial and lateral faces are more nearly vertical, and the popliteal apex is relatively higher up the shaft. We must not argue that these are only pathological results, for the very essence of the pathological condition might be that it released "determinants" long since inactive in the case of Recent Man. Before expressing a final opinion it seems desirable to consider whether similar approximations in character are to be found when we deal with the epiphyses.

(*d*) *Indices of the Proximal Epiphysis.* We turn now to the proximal epiphysis, and summarise our results in the following table.

TABLE LXII. *Indices of the Bust.*

Indices	Recent Man		Prot-simio-human	Dwarfs		
	Primitive	Advanced		Racial	Ateleiotic	Achondroplasic
Robusticity of Head	21·5	20·6	22·3	19·1	22·6	34·0
Ellipticity of Head	97·5	99·0	99·4	99·4	94·7	101·6
Ellipticity of Neck	67·8	75·3	78·0	78·1	71·4	99·5
Secondary Index of Neck ...	51·3	55·4	55·0	55·0	54·0	45·2
Lemotic Index	12·6	11·8	10·4	9·9	7·2	14·0
Head Bust Ratio	59·3	61·0	69·9	66·0	89·0	75·0
Primary Bust Ratio	17·7	17·0	15·8	14·4	12·95	22·4
Secondary Bust Ratio ...	17·9	17·1	16·0	14·6	13·05	22·5
Bust Shaft Index	20·7	20·05	19·0	16·8	15·1	29·4
Capital Ratio	10·5	10·3	11·1	9·5	11·5	16·8
Capito-bicondylar Ratio ...	57·9	58·6	58·1	56·5	59·2	57·8
Epiphysial Ratio	98·0	96·5	83·1	85·6	66·5	77·1

Here we can only dismiss two indices, the Secondary Index of the Neck and the Capito-bicondylar Ratio, because the Prot-simio-human's values lie in the Recent Man range.

[1] Five of these are already dealt with, for the Prot-simio-human values lie in the Recent Man range.

Turning to the Racial Dwarfs, we note that the value of no single index lies in the Recent Man range. In the following indices the value lies on the opposite side of the Recent Man range to the Prot-simio-human value: Robusticity of Head and Capital Ratio. This position follows from the fact that the *Racial* Dwarf has a head small as compared with the femoral length, while the Prot-simio-human has a relatively large head. Neither the ateleiotic nor the achondroplasic dwarfs resemble the racial dwarfs in this aspect. In the remaining eight indices the racial dwarf recedes from Recent Man in the same direction as the Prot-simio-human. In two of these indices, the Ellipticity of Head and the Ellipticity of Neck, there is close agreement, and in the Secondary Index of the Neck there is also identity. In proportions of head to bust and of bust to shaft racial dwarf and Prot-simio-human show tendencies in marked correspondence, namely the head is large as compared to bust and the bust is small as compared to shaft. These features are also maintained in the ateleiotic dwarf, where, however, the ellipticities are very divergent from the Prot-simio-human values. In Robusticity of Head, *i.e.* in the size of head relative to the femoral length, however, the ateleiotic dwarf approaches closer to the Prot-simio-human type. The correspondence of the racial dwarf with the Prot-simio-human in the proportion of bust to size of femur is the more noteworthy, as it is precisely here that the Prot-simio-human is less like the Chimpanzee (see Table LX, p. 434), *i.e.* less troglodytic and more hylobatic. We must accordingly admit in the bulk of the indices of the bust a considerable approximation of the racial dwarf to the Prot-simio-human, but this relationship appears to be associated with a hylobatic rather than a troglodyte tendency in both.

We now turn to the Ateleiotic Dwarf. Here only Ellipticity of Neck lies in the Recent Man ranges, so that we have nine remaining indices to consider. Of these Ellipticity of Head is on the opposite side of the Recent Man range to the Prot-simio-human value and may be dismissed. In two others, the Robusticity of Head and Capital Ratio, the Ateleiotic Dwarf is closer to the Prot-simio-human than the Racial Dwarf for the dimensions of his femoral head, owing to his infantilism, are more troglodyte as they are in the human child[1]. In the remaining six indices the deviations of the ateleiotic femur from that of Recent Man are markedly exaggerated, so that in all six the Prot-simio-human is nearer to Recent Man of the advanced races than to the Ateleiotic Dwarf. Had such a comparison been possible we should probably have found the *non-adult* Prot-simio-human closer to the Ateleiotic Dwarf. As it is, it is the proximal epiphysis of the Racial Dwarf—excepting the relative size of the head—which corresponds most closely to that of the Prot-simio-human.

Turning lastly to the Achondroplasic Dwarf, we have ten indices to discuss. Four of these, the Lemotic Index, the Primary and Secondary Bust Ratios and the Bust Shaft Index, can be at once dismissed, for they lie on the opposite side of the Recent Man range to the Prot-simio-human indices. In just the very characters wherein the Prot-simio-human femur approaches the hylobatic the achondroplasic femur tends to the troglodytic! In the remaining six indices the exaggeration of the troglodytic

[1] For example, if we deal with robusticity of the head, Rodriguez gives for 94 adult Japanese: mean ♂ 22·16, ♀ 21·07, but for 16 young Japanese regardless of sex: mean 22·30. See Bibl. 10, p. 29.

tendency is so great that all resemblance to the Prot-simio-human disappears. The Robusticity of the Head and the Capital Ratio exceed those of the male Gorilla, the Ellipticity of the Head is somewhat in excess of either Gorilla or Chimpanzee, the rotundity of the neck exceeds that of some femora of the Neanderthal Type, to which also the Head Bust Ratio approximates. The Epiphysial Ratio is also Neanderthalloid. Shortly, if the Achondroplasic Dwarf is to be looked upon as a reversion, it is a reversion in its proximal epiphysis rather to the Chimpanzee or to Neanderthal Man than to our Prot-simio-human.

We conclude, therefore, that as far as the indices of the bust are concerned, we can only find a valid association between the Racial Dwarf and our Prot-simio-human.

(*e*) *Indices of the Distal Epiphysis.* Lastly we turn to the Indices of the Distal Epiphysis, which are summarised in the table below. Of the ten indices three, the Condylar Lengths Index, Condylar Trochanteric Index and the Distal Articulation Ratio, may be dismissed at once from consideration, as their values for the Prot-simio-human lie in the Recent Man range.

TABLE LXIII. *Indices of the Distal Epiphysis.*

Indices	Recent Man		Prot-simio-human	Dwarfs		
	Primitive	Advanced		Racial	Ateleiotic	Achondro-plasic
Condylar Index	79·4	79·0	77·0	80·9	79·8	79·2
Condylar Lengths Index ...	97·4	100·6	100·0	100·5	113·9	96·2
Bicondylar Ratio	17·1	17·55	19·1	16·8	19·4	29·0
Band-radial Index	106·4	111·4	99·0	92·8	94·5	85·4
Condylar Trochanteric Index	15·0	14·6	15·0	14·4	16·6	23·0
Distal Articulation Ratio ...	16·5	15·5	16·0	15·8	17·6	26·1
Distal Articulation Index ...	91·1	89·05	84·0	94·3	90·9	90·1
Rotular Ratio	5·8	5·7	6·0	5·4	6·0	10·5
Rotular Index	35·4	36·75	37·4	34·3	34·0	40·3
Diaphysial Rotular Ratio ...	6·7	6·7	7·15	6·4	7·2	14·1

We now take the Racial Dwarfs. For Condylar Index, Bicondylar Ratio, Distal Articulation Ratio, Rotular Ratio, Rotular Index and Diaphysial Rotular Ratio, the indicial values lie on the opposite side of the Recent Man range to the Prot-simio-human. There can thus be absolutely no question of the racial dwarfs exhibiting a special association in distal epiphysis with the Prot-simio-human. They cannot for this portion of the femur be looked upon as preserving an earlier stage of Recent Man.

We next turn to the Ateleiotic Dwarf. Here in Condylar Index and Rotular Index the values for this dwarf are on the opposite side of the Recent Man range to those of the Prot-simio-human. In the Distal Articulation Index this dwarf lies in the Recent Man range. Thus for comparative purposes we have only to consider four indices. Of these three approach closely the Prot-simio-human values, namely the Bicondylar Ratio, the Rotular Ratio and the Diaphysial Rotular Ratio. The high values of these indices are what we should anticipate if the distal epiphysis in the

Ateleiotic Dwarf, as compared with femoral or shaft lengths, is exaggerated[1]. This corresponds to what we have found for the ateleiotic dwarf in the case of the proximal epiphysis, and marks an important distinction between the ateleiotic and racial dwarfs.

Lastly we consider the Achondroplasic Dwarf. In the proportions of the distal epiphysis as represented by Condylar Index and Distal Articulation Index he lies in the Recent Man range. But in the Bicondylar Ratio, Rotular Ratio and Diaphysial Rotular Ratio he enormously exaggerates the troglodyte tendency of the Prot-simio-human, *i.e.* the dimensions of the distal epiphysis are very great as compared to both femoral and shaft lengths. In Bicondylar Ratio, Rotular Ratio and Diaphysial Rotular Ratio he leaves the Gorilla far behind. But the Gorilla itself we should look upon as a development of the Prot-simio-human on extreme troglodyte lines. Thus we cannot look upon the achondroplasic femur as a reversion to the Prot-simio-human femur. In all these cases the latter is far nearer to Recent Man than to this dwarf. In the case of the Rotular Index, which measures the height of the patellar surface relative to the distal articulation breadth, the Prot-simio-human femur is close to that of the advanced races—more than four times closer than to the achondroplasic femur. Thus the achondroplasic femur tends to diverge in the same sense as the Prot-simio-human from that of Recent Man in about half the indices dealt with, but it enormously exaggerates the tendency. The source of this appears to lie in the shaft in the first place, some dimensional indices of the epiphysis being that of Recent Man. The shaft of the achondroplasic femur has developed laterally, but failed in normal longitudinal development.

In the development of the primates we find in the *Simiadae* and the *Simiinae* increasing size of epiphyses relative to shaft. The massive epiphyses appear to be developed in the first place. This gives the troglodyte character to the epiphysial indices. Then comes rapid increase of the size of shaft, the dimensions of the epiphyses not increasing in the same proportion. In the direct human line this culminated in Cromagnon Man, with an exaggerated shaft and lessened troglodytism in the epiphysial indices. The later reduction of shaft in Recent Man has the appearance of a reversion towards the apes, for the epiphyses have not decreased in the same proportion. The Prot-simio-human represents a stage when the length of shaft was increasing at a greater rate than the epiphyses. The resemblance to this stage of the achondroplasic femur seems to arise from more or less stationary epiphyses accompanied by a reduction in shaft length to a value even less than that of the Prot-simio-human femur. Our table, p. 434, shows quite close equality in size of the Prot-simio-human and achondroplasic epiphyses, but the former is accompanied by a shaft on the evolutionary up-grade, the latter by a shaft on the pathological down-grade, *i.e.* by one the individual growth of which has been checked. According to the extent of this checking we conceive that achondroplasic femora still closer to that of our Prot-simio-human could be found. But if they were, we should not speak of the result as a reversion. We

[1] Extreme robusticity is a feature of the non-adult or infantile femur: see for example Bumüller, Bibl. 81, S. 85 and our Plate LVIII. The shaft attains its transverse sooner than its longitudinal adult measurements.

understand by a reversion the sudden appearance of a latent determinant reproducing in recognisable form the characteristic organ of an ancestor. In the case of the achondroplasic femur certain characters only of an organ bear excessively exaggerated simian values. If we are to consider this due to the release of hitherto latent simian determinants, we must confess that the result produced is a hopeless mish-mash of human and simian features—such a nightmare as might arise from ape and human hybridisation. It is not a reversion to an ancestral type which we can suppose ever existed.

There is another aspect from which the relation of the achondroplasic femur to reversion may be considered, namely the appearance of anomalies which are characteristic features of the apes. The particular femur we have had under consideration has (i) a well-marked crural trough, (ii) a lateral projection surmounted by a well-marked ridge form of third trochanter, (iii) from the base of this a rugous area running spirally on to the posterior face—somewhat resembling the *fossa angulolateralis* in the Gorilla, (iv) a non-identifiable popliteal apex, (v) a popliteal area convex and ill-defined, (vi) a very deep and extensive *sulcus M. poplitei* as in the Gorilla and Chimpanzee, (vii) a great trochanter rising above the head, (viii) a badly shaped head with a large triangular shaped *fovea*; the articular surface, which is a good deal lipped, is cut away on the top of neck and on lateral face, but extended a good deal anteriorly and posteriorly, (ix) a super-trochlear fossa on the anterior face, *i.e.* a deep groove where epiphysis unites to diaphysis, (x) a patellar surface which is V-shaped, rather than saddle-shaped, (xi) a complete absence of pilaster. With the exception of (ix) and (x) these anomalies are simian, but it seems to us that their appearance in the achondroplasic femur only illustrates the principle we have before appealed to, namely, that pathological bones tend to exhibit reversionary characters, and it does not indicate that the bone as a whole is a reversion to a definite ancestor, the Prot-simio-human.

Throughout this consideration of the distal epiphysis we have omitted to consider the Band-radial Index. This index is greater than 100 in Recent Man, it is approaching 100 in the Prot-simio-human, and is less than 100 generally in *Simiadae* and *Simiinae*. Greater stress has been laid on it as a test of upright gait by Bumüller than we believe it deserves[1]. Still, it is remarkable that to the best of our powers of measurement racial, ateleiotic and achondroplasic dwarfs exhibit Band-radial Indices markedly below 100. Now, the achondroplasic and occasionally the myxoedematous if not the ateleiotic dwarf do show poor uprightness of gait, but as far as we are aware this has not been observed in the racial dwarf, although certain of the photographs of Bushmen and Akkas suggest a tendency for the bones to turn inwards. Either, therefore, the point has been overlooked, as points often are when not directly suggested, or the excess of the Band-radial Index over 100 is not essential —as we incline to believe—to upright gait. Anyhow, with due reservation as to the difficulty of accurate measurement, the low value of the Band-radial Index appears to be a simiine feature of all types of dwarfs, and in this feature they greatly exaggerate the Prot-simio-human value.

[1] Partly because we believe it to be over 100 in the *Cebidae*, and partly because it is very difficult to measure accurately.

(*f*) *Conclusions.* As a general conclusion to this brief investigation on the femora of racial and pathological dwarfs we would state that we find little evidence of either survival or reversional Prot-simio-human characters in the angles, general indices or indices of the shaft for either racial or pathological dwarfs. For the Proximal Epiphysis the Racial Dwarf does approach the Prot-simio-human, but the approach appears to be in those characters which are hylobatic rather than troglodyte. For the Distal Epiphysis the Racial Dwarf slips out; there is some resemblance to the Ateleiotic Dwarf in certain characters which depend upon relative exaggeration of the epiphysis in the latter, and thus produce troglodyte indicial values. We hold this is not a reversion, but solely due to the infantilism of the type. Again, although the Achondroplasic Dwarf exhibits in certain cases exaggerated simian characters, we believe these to be chiefly due to a failure in longitudinal growth of shaft and not to be Prot-simio-human reversions. There are certain characters in which the dwarfs are admittedly more simian than Recent Man, but we do not believe that any really substantial light can be thrown on the ancestry of Man by a study of the dwarf femur, whether racial or pathological in type.

CHAPTER X

COMPARISON OF THE FEMORA OF THE ANTHROPOIDS, OF PRIMOGENIAL MAN AND OF RECENT MAN

CONTENTS

		PAGE
(i)	Sources of Material and Criticism of its Value	445
(ii)	Anomalies of the Femur of Primogenial Man	453
(iii)	Comparison of quantitatively measured Characters in the Apes, Primogenial Man and Recent Man	464
	(*a*) General Remarks	464
	(*b*) Cromagnon and Recent Man	467
	(*c*) Verneau's Grimaldi Type	471
	(*d*) Position of Neolithic Man	476
	(*e*) Femur of the "Fringe" Races	476
	(*f*) Position of Galley Hill Femur	478
(iv)	Supposed Hylobatic Ancestry of Man	479
	(*a*) Arguments based on the Anomalies	479
	(*b*) Arguments based on quantitatively measured Characters	485
(v)	Final Problems	501

To this Chapter belong three major Tables:

Table I.	Measurements of the Femora of Primogenial Man and Comparatives	*to face p.* 450
„ II.	Cromagnon and Verneau's "Grimaldi Negroid" Types compared with Recent White and Negro Races	468, 469
„ III.	General Summary of Mean Values of Femoral Characters in the Primates	*to face p.* 472

(i) *Sources of Material and Criticism of its Value.*

In approaching this difficult subject we must stay to note that step by step we have been led beyond the initial scheme of our work—the study of the English femur—first to a consideration of the femora of other races of Recent Man, then to that of Primogenial Man and ultimately to those of a wide range of primates from *Tarsius* to the Gorilla. Nay, we can even add that we have gone further and examined in order to throw light on individual obscure points the femora of a great variety of mammals and birds. This extension of our topic has not been due to an incurable love of wandering far afield, but little by little we have been driven forward in the search for an explanation of those recurring anomalies in the human femur, which only too persistently indicated that they must be interpreted as vestiges of generic or at least specific characters in ancestral forms. There is not the least doubt in our minds now that in approaching our subject from the standpoint of the human

femur, we began so to speak at the wrong end. Not only should we have known better what anomalies to look for in the case of man had we started with the lower primates[1], but we should have learnt at once that quite a number of the measurements taken by the anthropologist are unsuitable, very difficult to make or even impossible in the case of the lower primates. Further, we should have realised that other measurements not hitherto taken in the case of the human femur are essential when we come to a comparison of that femur with those of the lesser apes and lemuroids. Notably important in this aspect are measurements on the patellar surface. It was only after a study of the lemuroid and lesser ape femora that we realised the evolutionary importance of the shape of the patellar surface, and recognised that some half-a-dozen indices ought to be based on measurements of this surface. The real importance of a number of indices not usually determined by anthropologists also became evident, for example the Pithecoid Index and indices formed on the direct and oblique lengths of *both* condyles. The necessity for using a proportion of the diaphysial length in fixing the popliteal section, instead of the 4 cm. rule, becomes evident even when dealing with Primogenial Man and the Anthropoids, and *à fortiori* is still more manifest when femora range from those of the *Hapalinae* to those of men of the Cromagnon Type. Again a wide study of the primate femur indicates how little a platymeric index *taken in the subtrochanteric region* can serve as an interspecial measure of femoral flattening, for the maximum flattening may take place either on the level of the trochanter minor or even above it[2]. The measurement of the popliteal apex and the formation of the indices associated with it become idle for the apex is indeterminable below the Anthropoids and is mostly guess-work even in their case. Again, the measurement of the vertical diameter of the head requires further standardisation where the articular surface—as in certain lower primates—is extended considerably onto the top of the neck. In addition the definition of the Bicondylar Width is laid open to question when it is found that in some individual cases among the primates the distance from epicondyle to epicondyle is not the maximum breadth. Or, again, what must we say to our definition of the maximum femoral length as from bottom of internal condyle to top of head when it is found that the length from external condyle to top of head

[1] For example a posterior fossa is a recurrent feature of the femur of a considerable number of lesser apes. It is a phenomenon which might occur in human femora with but little pilaster and might then very easily be overlooked. We did not search for it directly in examining our long series of London femora and therefore are unable to say dogmatically whether it actually does or does not occur as an anomaly in Man. What we have termed a "frontal pilaster" occurs in certain Lemuroids, we have found it as an anomaly in the human femur, but we had overlooked it before our attention had been attracted to it in the lower primates. The extensions of the articular surface of the femoral head in man have quite a different weight and need much more precise localisation after we have recognised their relationship to similar features which are generic characters of some of the lesser apes. The above cases are by no means the only cases in which a previous study of the femora of the lower primates would have been serviceable.

[2] Even when the flattening is subtrochanteric the value of the Platymeric Index for comparative purposes may be small, if one species invariably has lateral protrusion or ridges of the third trochanter type. The effect of the third trochanter in exaggerating the transverse diameters of the shaft may be observed probably in most of the lemurs and certainly in quite a number of mammals as low down as the pilastric section.

can actually be greater in the case of some apes? Clearly many of the purely anthropometric measurements would have been otherwise worded or wholly modified if they had been *ab initio* selected as suitable for determining the relative characters of all members of the primate group.

We have accordingly had to make certain modifications of old measurements, to introduce certain new measurements and to calculate a number of new indices in dealing with the femora of the lesser primates. These will be discussed, as far as is needful, in an Appendix to a later part of this memoir dealing more at length with the femora of the primates, but as we are publishing with this part a considerable number of the measurements a brief warning on the point is needful.

Some words must, also, be said here as to the descriptions of the patellar surface provided in the "Remarks" to the table of measurements of the primate femur. We have already stated that this varies very widely in the different groups and provides generic if not specific characters. In a considerable number of the lemurs we find the articular surface consists of a long groove or tongue raised above the general level of the shaft and running a considerable distance up the shaft[1]. This tongue or groove is weakened in one of two ways, either it is shortened until it reaches a more usual primate length, or the tongue may exist with only partial traces of the articular surface remaining upon it, just as if it were only partially or occasionally in use as a bearing for the patella. The tongue and the traces of the articular surface may become so faint that one doubts whether it can be said to be there or not. We have certainly found traces of the tongue in some of the lesser apes, and with less assurance we think we have noted it in very rare cases in the human femur. It is obviously therefore of considerable interest to measure the height of the patellar surface, to note whether there are traces of the tongue beyond the usually assumed boundary of the patellar surface[2], and to observe the extent to which it stands in relief above the general level of the shaft. But the height of the patellar surface must be taken relative to the size of the bone and this involves the formation of an index. This index may be taken on the maximum length of the bone, or, since the tongue may run a long way up the shaft, it may be better to take it on the diaphysial length. Again the breadth of the patellar surface and especially its relation to the height is of significance, but it is extremely difficult to get a satisfactory measure of the breadth of the patellar surface which shall be a fairly homogeneous dimension for all primates. Ultimately we felt compelled to take the width of the articular surface of the condyles, a measurement which has at least the advantage that it can be compared with the measurements taken on the Rothwell

[1] Similar patellar surfaces occur in a number of other mammals; we are inclined to think that they may have association with some faculty for springing, and an inquiry into the habits of animals with long-tongued patellar surfaces might lead to points of interest.

[2] In certain cases the patellar surface is patchy on the tongue and it is impossible to fix a definite boundary to the articular surface. The height of the patellar surface was measured on all the smaller femora with a reading microscope, but very occasionally it seemed easier to determine its boundary with the naked eye than by the hair of the microscope.

femora by Parsons and on the Portuguese femora by Tamagnini and de Campos. The ratio of this breadth to the size of the femur can be calculated, and what is more interesting the ratio to the size of the bicondylar width. We have accordingly determined for the femora of all our primates the following additional characters.

(i) *The Height of the Patellar Surface.* The bone is adjusted in the reading microscope so that the motion of the microscope is along the axis of the shaft. The reading hair is first made to touch at the centre (mid-trochlear point) the mid-trochlear curve and then carried forward till it touches at the highest point the proximal contour of the patellar articular surface. The space traversed by the hair is read as the height of the patellar surface. It is clearly the maximum height projected onto the axis of the shaft. The height along the axis of the shaft is not taken, because, particularly in the case of man, it does not give the maximum height. It does so more nearly in the case of the anthropoids and lower apes, for which the patellar surface is more nearly symmetrical, instead of possessing the usual lateral extension of the human articular surface[1].

In the case of the larger femora, especially the human, a knife edge was fixed perpendicular to an osteometric board. The femur was placed in the standard position on the board with its anterior face upwards and its mid-trochlear point against the knife edge. A horizontal bar perpendicular to the shaft axis was made capable of sliding in the direction of the shaft from the knife edge to contact with the proximal contour of the patellar articular surface at its highest point. The distance through which the bar slides measures the patellar height, p_h.

(ii) *Width of the Distal Articulation.* We tried in vain to obtain a satisfactory measure in the manner indicated by Parsons[2], and the difficulty increased as we passed to the lower primates. We were therefore driven to define the width of the distal articulation to be the maximum width of this articulation taken parallel to the standard horizontal and vertical planes and between the lateral border of the articular surface of the external and the mesial border of the articular surface of the internal condyle (w_d). The following indices were then formed:

(iii) *Distal Articulation Ratio* $= 100\, w_d/a$, where a is the maximum length.

(iv) *Distal Articulation Index* $= 100\, w_d/s$, where s is the bicondylar width. The Distal Articulation Index ranges in the primates from 79 to 96. It is highest in the *Indrisinae* (93·2), *Ateles* (92·9), *Cynocephalus* (93·2) and the Orang (93·3); it is low in Primogenial Man (79·4 in Neanderthal Man), while Recent Man (89) has in this as in other characters reverted to the ape (Gibbon and *Cercopithecus* circa 90).

(v) *Rotular Ratio* $= 100 p_h/a$. The Rotular Ratio is very high in *Tarsius* (9·2), the *Galaginae* (9·1) and *Lemurinae* (9·9). It is high also in the Greater Anthropoids

[1] We have not been able definitely to associate this human asymmetry with the exaggerated obliquity of the femur in man.

[2] Bibl. 111, p. 240. The measurement taken when the boundaries of the patellar surface are not parallel appears to depend on the thickness of the arms of the spanner. Our measurements for the Distal Articulation Width, ♂ 70·22, ♀ 62·25, are not comparable with Parsons' even after allowance has been made for the larger size of the Rothwell femora (♂ 74·90, ♀ 66·00, allowance made).

(7 to 8). It is low in Primogenial, especially Neanderthal Man (3·95), but Recent Man (5·7) has a value close to those of *Ateles* (5·75), and the Gibbon (5·7)—a gibbon-like human feature, but again probably a reversion.

(vi) *Rotular Index* $= 100 p_h/w_d$.

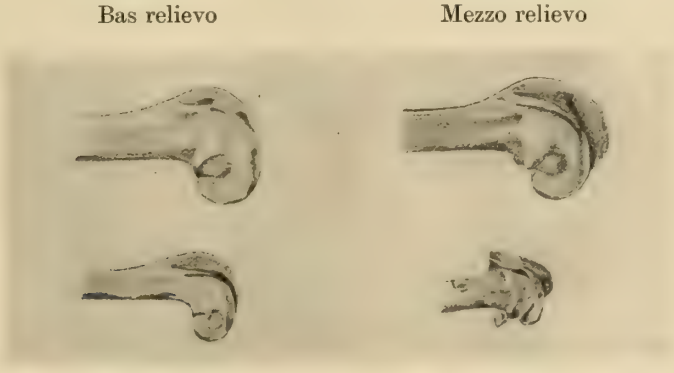
Tarsius (97) and Neanderthal Man (24) form two extremes. Recent Man (37) appears to have reverted from Primogenial Man towards more apelike values (Chimpanzee 39, Orang 42). *Hylobates*, fossil and recent, has a high value (48) which is more in keeping with that of the lesser apes. *Ateles* (38) on the other hand approaches the human value.

(vii) *Diaphysial Rotular Ratio* $= 100 p_h/l_d$, where l_d is the diaphysial length.

The conclusions to be drawn from this are very similar to those for the *Rotular Ratio*. The position of the *Lemurinae* (11·5), *Galaginae* (10·8) and *Tarsius* (10·6) at the head of the list is emphasised, Neanderthal Man (4·7) is still at the bottom, but Recent Man (6·7) is now somewhat differentiated from *Ateles* (6·1) and the Recent Gibbon (6·4), but not from *Dryopithecus* (6·6).

With regard to the elevation of the patellar surface above the shaft the conception of *relievo* is so natural that we have adopted its terminology. When the patellar surface is accurately level with the shaft as is usually the case in Man we term it *piano*; when it is in slight relief as in the Orang or occasionally in Man, it is *bas relievo*. The patellar surface of *Tarsius* is in high relief *alto relievo*; while medium relief *mezzo relievo* occurs in certain baboons, *e.g. Papio maimon*. The following cut illustrates the nature of such relief in the patellar surface.

Examples of Patellar Surface Relief.



We have described the patellar surface as "short" when it scarcely reaches to the height of the top of the condyles on the posterior face; as "medium," when it about reaches this height, and as "long" when it sensibly exceeds this height. (See the Remarks to the Measurements of the Femora of the Primates in Atlas, Part II.)

The above indications should suffice to justify our use in the present chapter of

the indices of the patellar surface as discriminants in our search for the simio-human ancestor.

Before entering on a general discussion we should like to impress upon the reader that the material which we have been able to collect is rather a suggestion of what it is necessary to do, than a summary of what has been adequately done. We should be the last to lay overmuch stress on values obtained from casts and photographs or on the few measurements we have been able to obtain during the past few years on the anthropoid femora in the Laboratory itself. But the continuous war-work of the Director and Staff since August 1914 has hindered the completion on really adequate lines of the work started on a much more limited scale in 1895. As our interest and knowledge grew we purposed a complete measurement of all the anthropoid material available in British museums, and a continental visit to confirm or correct the measurements on the femora of primogenial man. Under war conditions the former has had to be postponed for an indefinite period, and the latter as far as the present writers are concerned is unlikely ever to be possible.

While admitting the temporary character of our determinations we should by no means have published them had we not considered that the accompanying tables, if the reader will only remember that they are not final ones, give more information and more reliable information in a single work than has hitherto been available.

At the same time considering the size of our sample we have been rather surprised to note how fairly closely our own measurements for the anthropoids accord with those of other writers. The present table of comparative results was printed at a fairly early stage, as we needed the information for reference in a concentrated form. We overlooked the anthropoid material in Antony and Rivet's paper of 1907. This gives: (*a*) the bicondylar width of 26 gorilla femora as 84·1; our value for five was 84·1, or when the two femora (B. W. = 101) of the gigantic Edinburgh gorilla of Hepburn are added, 88·9; (*b*) the bicondylar width of 19 chimpanzee femora as 65·8; the three chimpanzees of our table give 65·2. On the other hand they give (*c*) the ellipticity of the neck of 15 gibbon femora as 80·9. Our gibbon femora have an index of 73·9. We do not attribute this difference solely to the individuality of our sample. The diameters of the neck are characters which sadly need standardisation and, it has been our experience, are only of comparative value when measured by the same authority, or when practically identical methods have been employed in their determination. A comparison of the first and second columns under each anthropoid in the table will indicate to the reader the extent to which our measurements of isolated femora are in accordance with the more numerous series of other authors, when such are available. Measurements of anthropoid femora are in our experience very infrequent and are as a rule confined to certain very special characters; no writer, as far as we are aware, has hitherto published a complete series of measurements on any single anthropoid femur.

Passing to the femora of primogenial man we have been struck by the complete inadequacy of the descriptive memoirs of the great finds. This applies not only to the osteometric side, which has been sadly neglected, but even to the description of

anomalies. It applies not only to early writers, such as E. T. Newton on the Galley Hill femur (1895)[1], Sir Richard Owen on the Tilbury femur (1884)[2], and Dubois on *Pithecanthropus erectus* (1894), to whose omissions we have frequently made reference, but to Marcellin Boule's great memoir of 1911—*L'homme fossile de La Chapelle-aux-Saints*—with all its splendid illustrations and refined technique[3], and in a lesser

[1] The osteometric data provided are as follows: Maximum Length "about 419 mms." (16½ inches, which equals 419·1 mms.) in text, but as 421 mms. in table (Bibl. 69 *bis*, p. 509); Transverse Diameter "about 30 mms.," and Antero-posterior Diameter (avoiding *linea aspera*!) "above" 25 mms., both about middle of shaft; Length of Condyles, 62 mms.; V. Diameter of Head, 48·5 mms.; neck and shaft "at the usual angle." Neck said to be flattened and shaft stated to be nearly straight. We make the ellipticity of the neck considerable (69·6?) and therefore the index less than the human mean value (76). On the other hand we get very considerable bowing. The Primary Index of Bowing is 2·7 on the cast and 3·1 as obtained from Newton's own illustration (Plate XVI of his paper). It is clear that the osteometric value of Newton's paper is small.

[2] Owen's paper (Bibl. 33 *bis*) is still slighter in osteometric detail. He tells us that the "total length of bone," whatever this may be, is 16½", the cast does not suggest that any "total length" could be found. The only other measurement given is "circumference" 3", 9 lines. Noteworthy anomalies are, however, registered, namely a marked third trochanter and a considerable tubercle on the anterior face at the lower end of the intertrochanteric line. It will be remembered that W. Roger Williams (*Journal of Anatomy and Physiology*, vol. XIII. p. 212, London, 1879) considered two tubercles—the inferior and superior cervical tubercles—to be marked terminations of the *linea intertrochanterica*, the latter is now usually termed the tubercle of the femur, and the former is what Owen records on the Tilbury femur.

[3] To justify this criticism we refer to pp. 150—161, which are entitled *Fémurs*. We have endeavoured to extract the data for the La Chapelle-aux-Saints femur from these pages, but largely in vain. Boule gives us, it is true, the Maximum Length 430, the Pilastric Antero-posterior 31, and Pilastric Transverse 29, and the Index of Robusticity 14 (which may be compared with our values from his photographs). All the other values he gives are stated vaguely as means for 3 or 7 or 8 femora of the Neanderthal Type, and we often do not know which of these famous femora he has included, and how he has obtained his measurements for them. Thus, as example, we may cite "Quand on compare la longueur du col, comme la prennent la plupart des auteurs avec la longueur de fémur en position, on obtient *l'indice de longueur du col*....L'indice moyen de quatre fémurs de Néanderthal, Spy, La Chapelle et La Ferrassie est de 17·4." It appears to us that Boule is here not dealing with the length of the neck, but the length of the bust, *i.e.* with the Secondary Bust Index and not the Lemotic Index, nor does he indicate how widely femoralogists differ in "neck" measurement. Our mean value in the case of four femora of the Neanderthal Type is 17·45, agreeing well with his mean of three, but our value is obtained because the gibbon-like proportions of the Neanderthal femur in this index are counterbalanced by the gorilla-like proportions of the La Chapelle-aux-Saints femur. We have not Boule's own measurement of the "longueur du col" to confirm this point. Again the Platymeric Index of the La Chapelle-aux-Saints case is lost under the bald statement that "sa valeur moyenne, pour les fémurs fossiles est de 80." We make it on the average of four cases 77·6, and it actually would be considerably lower but for the high and unverified value of 85·1, which we have given to La Chapelle-aux-Saints. Again Boule tells us that the Pilastric Indices of seven Neanderthal Type femora give a mean of 99. He does not state which femora; we find it for four, using Boule's and not our own value for the La Chapelle-aux-Saints femur, 105·4. We are quite unable to say whether the difference is due to the femora chosen to represent the type, or to the values given to the indices in those femora. For the Collar Angle Boule gives the mean of six cases—not further specified—as 116°. We find the mean of four cases to be 115° in close agreement. But Boule does not state what is true if our measurement be correct; that while La Chapelle-aux-Saints agrees exactly with Spy and *Homo mousteriensis* (*Hauseri*) at 112°, it is the Neanderthal value of 123°·5 which really raises the average to 115°. He measures the bowing by the curvature method of Antony and Rivet and gives the mean radius of curvature as 72·4 for *seven* Neanderthaloid femora, without stating which or giving individual values. We could continue the

degree to Verneau's splendid volume on *Les Grottes de Grimaldi*[1]. Indeed Boule and Verneau do not provide as complete a system of measurements as Fraipont and Lohest did for the Spy femora in 1887[2]. As for Schaaffhausen in his account of the original Neanderthal find published in 1858[3], he tells us that two "ganz erhaltenen Oberschenkelbeine" were discovered, but only provides four measurements taken on one of them! Somewhat more complete measurements, of the accuracy of which, however, we are not entirely convinced, were taken by Klaatsch in the cases of *Homo mousteriensis* (*Hauseri*)[4] and of *Homo aurignacensis* (*Hauseri*)[5], but these leave many measurements to be added. Klaatsch in 1910 has also provided relatively the most complete set of measurements we have come across of the Neanderthal femora R. and L. and Spy I and II, but it is quite clear that his methods of measurement must have differed much from ours[6]. In 1910 Capitan and Peyrony announced the discovery of two human skeletons of the Mousterian epoch, but provided no details, which they then said were to follow[7]. We have not yet come across any detailed study.

Such are the chief sources of the material for the study of the femur of Primogenial Man and the reader who will examine them from the standpoint of the needs of modern femoralogy, will not, perhaps, be surprised that under the recent war conditions we were driven to working on the photographs and the casts. This action also received support from the divergences we found between our measurements on the casts, and those of Fraipont and Lohest and again of Klaatsch. In the case of the latter authorities we must suppose them to have been measuring the originals, yet they are far from being themselves in complete agreement, and their values differ very considerably from our measurements on the casts. Some setting of the mould and some setting of the cast is of course certain, but the differences, especially of the angles, are greater than we should have anticipated. We hold that in large part, as in taking the platymeric, pilastric and popliteal diameters, there is

list, but the above instances must suffice to serve as basis for our criticism. At the same time we find as a rule a very considerable degree of agreement between our mean values and those given by Boule.

[1] Bibl. 94 *quater*, see pp. 51—55, 61—62, 107—109, 154. Verneau gives the Maximum and Oblique Lengths, the two Platymeric, the two Popliteal and the two Capital Diameters, and the Bicondylar Width. In three cases he provides the breadth of the Distal Articular Surface. Of indices he calculates only the Platymeric and Popliteal (in the Table, p. 154, he gives the absolute measurements of the R. femur of the Grotte des Enfants subject, but they appear to be combined with the indices of that femur, although in the Table on p. 108 the values for both sides are provided). On p. 109 he gives the obliquity for two out of his eight femora, but does not state to which side of the individuals dealt with they refer. On the same page he says "l'angle cervico-diaphysaire varie de 109° à 117° chez nos sujets," but he does not state which values the individual femora have. This is the more vexatious as the individuals belong to such different types. It will be seen that the osteometric data provided by Verneau are very slender. We have added as many measurements as we could safely take from his illustrations. But these illustrations are limited to the anterior view of four and the posterior view of three of the nine or ten femora to which he refers.

[2] Bibl. 42 *bis*, pp. 651—656.

[3] Bibl. 5 *bis*, S. 457.

[4] Bibl. 101 *bis*, S. 287—297.

[5] Bibl. 103 *bis*, S. 273—338, and Bibl. 102 *bis*, S. 513—577.

[6] Bibl. 103 *bis*, S. 329 and *Anatomischer Anzeiger, Ergänzsheft zum XIX Bd.* 1901, S. 121—145.

[7] Bibl. 104, pp. 48—53.

divergence of method[1], and on that account we believe that until we can ourselves measure the originals, our cast and photograph measurements are more comparable with our other measurements—not necessarily better—than those of these authorities.

Our interest in Primogenial Man may be of two kinds; we may either discuss the characters which are considered anomalies in Recent Man, or we may feel our way toward evolutionary suggestions by comparing the series of measurements.

(ii) *Anomalies of the Femur of Primogenial Man.*

We can record the following of the anomalies:

Trochanter tertius. This is well developed in both femora of the Neanderthal Man, and in each of the single surviving femora of the Spy I and Spy II. According to Boule[2] the femur of La Chapelle-aux-Saints does not show a third trochanter, but the Neanderthalloid femur of La Ferrassie does. *Homo mousteriensis* (*Hauseri*) is defective at this point, and of *Homo aurignacensis* (*Hauseri*) we can find no record on this point. The Galley Hill femur has a well marked pilaster running up to a ridge followed by a nipple form of third trochanter. Verneau's Cromagnon specimen shows no third trochanter nor do his Negroid Type femora. It would appear therefore that the third trochanter is more or less characteristic of Primogenial Man of the Neanderthal Type, but wanting in the Cromagnon and Negroid Grimaldi Types. The third trochanter while anomalous in the anthropoids and lesser apes is characteristic of the Lemurs. The *fossa hypotrochanterica* is well marked in Neanderthal R., and is quite definite in Neanderthal L. and in Spy I and Spy II. According to Boule[2] it is not found in the La Chapelle-aux-Saints femur, but appears in La Ferrassie I. La Ferrassie II is defective at this point. Galley Hill has a slight hypotrochanteric fossa on the mesial side of the ridge preceding the third trochanter. The *fossa* also appears in all Verneau's femora whether of Cromagnon or Negroid Type[3]. *Homo mousteriensis* (*Hauseri*) is defective at this point. We may conclude that the *fossa hypotrochanterica* is usual in all types of Primogenial Man. This fossa is found in the Chimpanzee. There is subtrochanteric lateral protrusion of the anterior face in Neanderthal L. and Spy I. It occurs also in the original Cromagnon and in the Tilbury Femora. The

[1] Thus Klaatsch appears to take the platymeric diameter just under the trochanter minor, while we seek for the minimum antero-posterior diameter in the subtrochanteric region and measure the transverse at this height according to Manouvrier's rule. Klaatsch takes the pilastric diameters in the "middle" of the shaft—without saying how the middle is to be determined. We take the maximum antero-posterior diameter, which is not always at, if near, the middle, and the transverse at the same height. Our method of finding the collar angle also differs, and probably other processes will differ in like manner. We can find a further illustration in the torsion:

	Neanderthal	Spy R.
Klaatsch	9°·5 (R.)	14°·0
Rodriguez	—	13°·5
Rivet	13°·0 (R.)	20°·0
Pearson	6°·0 (L.)	16°·0

It is clear that the methods used are divergent in the extreme!

[2] Bibl. 106 *bis*, p. 158.

[3] Verneau speaks of it as a great depression, which in some of his specimens was 50 to 55 mm. long. Bibl. 94 *quater*, p. 107. Boule states that it exists on all femora of the Cromagnon Type. Bibl. 106 *bis*, p. 158.

Galley Hill femur is defective but there is evidence for probably marked antero-lateral protrusion. It is indicated but less emphasised in *Homo mousteriensis* (*Hauseri*). It is slightly evident in La Chapelle-aux-Saints and La Ferrassie I. It is probably there in La Ferrassie II[1]. The lateral protrusion also exists both in Verneau's Cromagnon and in his Negroid femora. The reader will easily recognise this protrusion in the plates of our Atlas devoted to Primogenial Man. It is a well marked feature of the gibbon's femur, and is still more marked in the Lemuroids. Another pithecoid character is the relative height of head and great trochanter when the femur is orientated to the standard horizontal plane. In this case the trochanter of the gorilla's femur outtops its head, while that of the Chimpanzee is on the same level. In the bulk of normal human femora the head is considerably above the level of the top of the great trochanter. In *Homo mousteriensis* (*Hauseri*) there is an approach to the Chimpanzee level (see our Plate XLVII). In La Chapelle-aux-Saints the great trochanter is relatively high[2]. In Ferrassie I the great trochanter appears to outtop the head[3]. This again seems to be approached in Verneau's Grimaldi negroid old woman, and the trochanter is, relative to the head, much higher in his Cromagnon Type femur than is usual in Recent Man[4]. Our Plate LI indicates the same feature in Neanderthal L. The defectiveness of the Spy femur hinders any judgment on the point. It is a marked feature of many of the Lesser Apes and the Lemuroids. On the other hand the Orang resembles Man in having the head markedly higher than the great trochanter. *Pithecanthropus erectus* does not show this pithecoid femoral characteristic (see our Plate XLVI).

The crural trough is to be noted in several of these fossil femora. In Galley Hill it is short longitudinally, but very broad. There is a marked crural trough in the original Cromagnon, and crural depressions in Neanderthal and Spy. In Verneau's material to judge by his photographs it also probably existed in the Cromagnon Type femora.

There is a wide short trough in Ferrassie I[5]. It is difficult to judge of La Chapelle-aux-Saints and the *Homo mousteriensis* (*Hauseri*)[6] as they have been restored in this neighbourhood. *Pithecanthropus erectus* appears to have a well marked trough. Another feature which Primogenial Man shares with Gorilla and Chimpanzee is the horizontality of the proximal border of the neck when the bone is orientated to standard horizontal and vertical planes. This is marked in *Homo mousteriensis* (*Hauseri*), in La Chapelle-aux-Saints, in La Ferrassie I, in the original Neanderthal, and in Spy I as restored by Boule. It is not true of Recent Man, and in this respect *Pithecanthropus erectus* may be said to resemble either Recent Man or the gibbon according to our bias. It is true of both Verneau's Cromagnon and Negroid Type femora.

[1] Bibl. 106 *bis*, Plate IV, Figs. 3 and 3 *a*; also Fig. 78, p. 156 and Fig. 79, p. 157.
[2] Bibl. 106 *bis*, Plate IX.
[3] Bibl. 106 *bis*, p. 157, Fig. 79 and his remarks in text.
[4] Bibl. 94 *quater*, Plates X and XI.
[5] Bibl. 106 *bis*, Fig. 78, p. 156.
[6] Possible suggestion of a trough.

According to Klaatsch the cylindrical form of the shaft is maintained closer to the distal end of the femur, in the case of Primogenial Man, than in Recent Man. For Recent Man we have a more trumpetlike shape of the distal end of the shaft[1]. We have already reproduced (p. 10) Klaatsch's illustrative diagram. Boule also lays stress on this point and finds in it a closer resemblance of Primogenial Man of the Neanderthal Type than of Recent Man to the monkeys and *Pithecanthropus erectus*. Now this is a point where we have already indicated that we consider, not description, but actual measurement is in the right place. For this purpose we introduced the Soffit Index, and the Index of Gracility (Lower) is also of value. Let us take the latter first:

SUBTABLE I. *Index of Gracility (Lower).*

Anthropoids	Gibbon (4)	84·8	84·8
	Chimpanzee (3)	77·9	74·9
	Orang-utan (3)	73·7	
	Gorilla (10)	73·2	
Pithecanthropus erectus		76·7	76·7
Primogenial Man (Cromagnon Type)	Cromagnon	81·2?	75·8?
	Tilbury	81·2?	
	Verneau: La Grotte des Enfants L.	63·1?	
	„ La Barna Grand L.	67·6?	
Recent Man	17th century Londoners ♂	71·04	70·9
	„ „ ♀	70·75	
Primogenial Man (Neanderthal Type)	La Chapelle-aux-Saints R.	77·8?	70·3
	Neanderthal L.[2]	75·9	
	Spy I R.[2]	69·9	
	Homo mousteriensis (*Hauseri*)	57·6	
	Galley Hill	58·9	65·8?
	Homo aurignacensis (*Hauseri*)	72·7	
Grimaldi Negroid Type	Old Woman	70·5?	58·0?
	Youth	45·5?	

Now a special point to be noted is the great range in the individual groups. But if we can trust the mean value the Neanderthal Type of Primogenial Man so far from approaching the anthropoids in the cylindrical character of the lower half of the femur is as gracile as Recent Man. The Cromagnon mean is based on absolutely opposed components, every one of which is of doubtful validity, for we have had to determine them in the first two cases from the casts of the defective bones and in the second case from Verneau's illustrations. The mean, if it shows anything, indicates that the Cromagnon Type was more pithecoid in this respect than the Neanderthal Type. Galley Hill is more gracile than the average of Recent Man, but Hauser's sample of Mousterian Man is still more gracile, and both these femora are more gracile than Hauser's Aurigniac Man which Klaatsch dubs of "orangoid" gracility. The

[1] Bibl. 87, S. 662.

[2] Values for this Index deduced from Klaatsch's measurements (*Anatomischer Anzeiger, Ergänzsheft zum XIX Bd.* 1901, S. 128 *et seq.*) are wholly different. But then his measurements of the popliteal widths are markedly different from ours. He gives for popliteal widths, Neanderthal L. 37 and Spy I R. 36, as against our 40·6 and 42·9!

fact is that "gracility," when expressed numerically, may be less for one feature of Orang and Aurignac Man than it is for Gorilla and Neanderthal Man, while it far exceeds it in a second. A general description of the femur of one type as more gracile than another carries us very little onward unless we have defined gracility and actually measured it for a variety of characters. Galley Hill with the present criterion is a "gracile type," but then it has to us the appearance of post-mortem erosion along the centre of the shaft, or at least of ante-mortem feebleness[1]. Verneau's Grimaldi Negroid Type is the most gracile femur of all, if it were legitimate to club the "Adolescent" with the "Old Woman"—a doubtful enough procedure, and not justified by the modern negro femur being especially gracile[2].

Our general conclusion must be that the cylindrical or pithecoid character claimed by Klaatsch and Boule for the Neanderthal Man lacks quantitative demonstration. It is possible, however, that it is optically produced by the distal epiphysis being relatively large as compared with the lower portion of the popliteal area. In other words that the trumpetlike impression of the distal portion of the femur is produced by carrying on the walls of the trumpet into the distal epiphysis, while an enlarged epiphysis cuts off the trumpet at the end of the popliteal area. This is a point which the Soffit Index should properly test. The table on the following page indicates the data we have been able to collect.

[1] It may be as well here to give our views on the Galley Hill femur. We came to it with considerable prejudice owing to the uncertainty of its geological records, and the manner in which the find has been used for wide-sweeping conclusions based on little accurate measurement. A careful examination of the femur has, however, convinced us that it possesses many signs of great antiquity. It is not the single factors, but the combination of them, which should be emphasised. There are signs of marked muscularity, the coexistence of third trochanter, hypotrochanteric fossa, and crural trough, the remarkable trochanteric flatness and marked antero-lateral protrusion, marked supra-condylar eminences on both sides, convexity of popliteal area, all features which, occurring more or less isolatedly in Recent Man, are relatively rare when combined. The great trochanter and parts of the head having been broken off, make the proximal epiphysis now *appear* much more slender than it really was. It is impossible to judge accurately of what the original massiveness of the condyles may have been for they have largely disappeared. If the cast be placed alongside that of Hauser's Mousterian Man, it is by no means obvious that the Galley Hill was of a different type. Its head and condyles if completed would probably not have been markedly smaller, and it has the same exaggerated gorilloid form of neck. It has a more marked pilaster and is more slender in the pilastric region, if that be not due to post-mortem causes. In these respects it is more modern. We have just seen that it is not more gracile in the distal portion of the shaft. It might well be a small and pathological specimen of the Neanderthal Type. It carries the combination of anomalies we have occasionally found in what would be described as feeble or pathological specimens of recent femora which may well be reversions. It may, we think, be placed according to individual judgment either as a link between Neanderthaloid and Recent Man, but nearer to the former, or as a feeble or pathological specimen of the former. On any careful examination it could not be placed as a femur of Recent Man in the same sense that the Trinil femur would undoubtedly have been placed, had it not been found associated with the cranium of *Pithecanthropus erectus*. We are with those who claim true antiquity for the Galley Hill find, but we cannot agree with them in considering the femur as identical with that of Recent Man, nor in classifying it with *Homo aurignacensis* (*Hauseri*). We think Klaatsch has exaggerated the correspondences and neglected many of the divergences between the two: see Bibl. 103 *bis*, S. 328 for Klaatsch's views.

[2] It is also shown on our p. 303 that the Index of Gracility (Lower) increases with age, which probably accounts for the low index of the adolescent.

The table presents points of interest. In the first place we lay no stress on the position of Verneau's Grimaldi Negroid Type. It is acquired solely by the high values in the case of the "Adolescent." The "Old Woman's" femur has a value close to that of Recent Man. It may be indeed merely an indication of growth-change, the Adolescent having a Popliteal transverse Diameter relatively great as compared with the Bicondylar Width[1]. The main feature of the table is the manner in which Primogenial Man and Recent Man divide the Anthropoids. In the Gorilla the Popliteal Width is 57 %, in the Gibbon only 43 %, while in our 17th century Londoners it is 50 % of the Bicondylar Width. Cromagnon Type stands between the Gorilla and Recent Man, and the Neanderthal Type between Recent Man and the Gibbon. We

SUBTABLE II. *Soffit Index.*

Primogenial Man (Grimaldi Negroid Type)	Old Woman (1)	48·1	54·4
	Adolescent (1)	60·8	
Anthropoids (A)	Gorilla (7)	56·7	52·15
	Orang-utan (3)	47·6	
Primogenial Man (Cromagnon Type)	♂ La Grotte des Enfants R.	54·44	52·00
	,, ,, L.	51·65	
	♂ Baonesso de Torre I R.	51·65	
	,, ,, ,, L.	48·42	
	,, ,, II R.	53·06	
	,, ,, ,, L.	52·75	
Galley Hill Man		50·9?	50·9?
Recent Man	17th century Londoners ♂	49·99	50·43
	,, ,, ♀	50·86	
Pithecanthropus erectus		46·2	46·2
Primogenial Man (Neanderthal Type)	*Homo mousteriensis* (*Hauseri*)	49·8	45·78
	Spy I	45·8	
	Neanderthal L.	45·3	
	La Chapelle-aux-Saints	42·9?	
	La Ferrassie I	45·1?	
Aurigniac Man	*Homo aurignacensis* (*Hauseri*)	45·3	45·3
Anthropoids (B)	Chimpanzee (3)	44·4	43·6
	Gibbon (3)	42·8	

thus find confirmation of the view that the less trumpetlike shape of the Neanderthal Type is an optical effect produced by greater relative width of the distal epiphysis. In this character, as far as we can judge in the defective state of the Galley Hill femur, that femur is separated from Hauser's Aurigniac Man by both Recent Man and Neanderthal Man. *Pithecanthropus erectus* lies between Recent Man and the Neanderthal Type. But here we must at once state that any argument based on the position for one character of a *single* individual of a race is of very little value. As far as this character is concerned Galley Hill might be a variant of Recent Man or of Cromagnon Man or of Neanderthal Man, and *Homo aurignacensis* (*Hauseri*) might be a variant of Recent Man or of Neanderthal Man.

It does not seem to us then that the claim to a "cylindrical" shaft as a special feature of the Neanderthal Type is very well founded.

[1] Modern Negroes, see our p. 306, have a Soffit Index of 45; this is not gorilloid, but on the contrary gibbonlike.

A further anomaly noted by Boule and stated by him to associate the Neanderthal Type rather with the *Cynopithecidae* than the Anthropoids is the circular rather than triangular[1](!) shape of the pilastric section. This matter will be best considered when we deal with the Pilastric Index.

Boule, like Bumüller and Klaatsch, considers the problem of the relative size of the condyles. Following Bumüller he says that (i) in Man the External Condyle is larger than the Internal Condyle, (ii) that in the Apes this is reversed, (iii) that in Primogenial Man there is equality of the condyles[2], (iv) that in certain of the inferior apes they are also equal. On the basis of these statements Boule suggests that Primogenial Man is closer in this character of the condyle to some of the inferior apes than to the anthropoids. In reference to this matter we would point out that (*a*) the condyles are extremely nearly equal on the average in Recent Man, the Condylar Lengths Index being 100·5 : see our p. 407. There is no adequate evidence at present to show that they are more nearly equal in Neanderthal Man. On the contrary we find the Condylar Lengths Index = 110·7 for primogenial man of this type. This is markedly in excess of the anthropoids (81 to 97) and approaches more nearly the value in *Semnopithecus* (103) and *Dryopithecus rhenanus* (105). The majority of the *Simiadae*, however, have low values under 100. In the majority of *Cebidae* and the Lemuroids it exceeds 100, being as high as 111·4 in the *Indrisinae* and only really low in the *Lorisinae*. It would be better therefore to say that Recent Man is nearer to *Cercopithecus* and *Semnopithecus* than to the Anthropoids, and that Neanderthal Man finds his nearest approach in certain of the *Cebidae* (*Hapalinae*, 106) and the Lemuroids, *i.e.* is still further removed than Recent Man from the Anthropoids. It is a grave misfortune that we have no condylar lengths for either Cromagnon or Grimaldi Types, and that the condyles of Galley Hill are very defective. Even the Neanderthal values are not very certain. Still it is fairly clear that, as far as Recent Man is concerned, we can (*b*) add another to the considerable number of cases in which Recent Man is closer to the lesser apes than to the anthropoids, and (*c*) it is by no means yet demonstrated that this closeness is as great in Neanderthal Man, unless we go back to considerably more primitive primate forms. This question can hardly be properly discussed, however, until far more elaborate biometric studies of the femora of the lesser apes have been made than at present exist[3].

[1] Hrdlička has published a paper (Bibl. 84 *bis*) asserting that the triangular shape is the fundamental form of the shaft in all the human long bones. We venture to differ from this view. The rotiform section seems earlier in the femur in man and the pyriform to be later. It appears to us not impossible that the rotiform section of certain of the lesser apes developed on the one hand into the maliform of the anthropoids and through the rotiform of the Neanderthal Type to the pyriform of Cromagnon. Nor can we at present accept Hrdlička's argument which appears based on change of shape of bone being due to muscular activities.

[2] Boule seems (Bibl. 106 *bis*, p. 160) to base his statement on the equality of the condyles in La Ferrassie II.

[3] Of anomalies which occur in Recent Man, but are not general in Primogenial Man, Boule notes facets prolonging the articular surface of the head onto the neck on the *anterior* face in the case of both La Ferrassie femora (Bibl. 106 *bis*, p. 156), and on La Ferrassie I a prolongation of the upper posterior surface

A last anomaly of the femora of Neanderthal Type to which we may briefly refer is their marked Bowing. This they seem to share with the Cromagnon Type. With the exception of the nearly straight femur of the gibbon, the anthropoid bowing is greater, but only slightly greater, than that of Recent Man, but the Bowing of both main types of Primogenial Man is very considerable, and should, we think, be associated with the progress towards a more perfect vertical gait. Some most exciting evolutionary problems must be associated with the development of the massive pilaster in the tall Cromagnon Race, but the appearance of this pilaster was not contemporary with a disappearance of the excessive bowing. It would at times almost appear as if a new and advantageous character had to be fully developed or even developed in excess, before a marked characteristic of an earlier kind tended to disappear. In any long series of femora isolated almost pathological individuals will be found with marked bowing and emphasised pilastry. It has been even suggested that the existence of a large amount of bowing tends to produce on the compression side of the strut the actual growth of the pilaster[1]. The question then arises: How is the pilaster preserved as a racial character while the bowing is reduced to much more moderate proportions? The mechanical origin of the pilaster seems to fail when we observe it associated with relatively straight shafts. The believer in the inheritance of acquired characters will find, perhaps, small difficulty in dropping the excessive bowing after the pilaster has been acquired. In Mendelian language the factor for the pilaster may have been acquired, but we should hesitate to believe that in femora of the Cromagnon Type it was not congenital, but acquired by use. They are certainly in no way pathological femora. We ourselves give little credence to the pure mechanical origin of either bowing or pilaster. Granted, however, the release or acquirement at a given epoch of a factor for pilastry, how was the factor for extreme bowing, at first associated with it, lost? The problem appears to be rather akin to some of those with which Morgan has recently been dealing. The existence of a character A, the possibly rather abrupt appearance of a second character B, the association of A and B for a period, and then the disappearance or partial disappearance of B[2].

In the following table we have added various cases of Primogenial Man to our earlier bowing material. We have already criticised Antony and Rivet's method of dealing with Bowing. Unfortunately while it is possible from our measurements to obtain the radius of pseudo-curvature, it is not possible from Antony and Rivet's mere

of the lateral condyle of the left femur (*l.c.* p. 159). To the latter facets Havelock Charles has drawn attention: see our pp. 104—6.

[1] These apparently pathological femora, combining marked bowing and pilastry, may be considered by some as reversions, and indeed not the less so because they may be pathological, for we incline to the view that defective and feeble organs have *sui generis* a tendency to exhibit as anomalies reversionary characters.

[2] It should be clearly grasped what the supporters of the mechanical theory have got to account for: (*a*) marked bowing causes the development of a marked pilastry, (*b*) such marked pilastry has got to be inherited, (*c*) being inherited it checks the excessive bowing. (*a*) and (*c*) are possibly conceivable on mechanical grounds, the difficulty is in appreciating how (*b*) comes about. No doubt the cells on the

statement of that radius to obtain either of our Indices of Bowing although they must have taken our Diaphysial Chord and Subtense without, however, publishing the record of them. We are therefore compelled for any comparative purpose to deduce Antony and Rivet's pseudo-curvature from our measurements. We have introduced it in the last column but one in order to increase the data for gorillas and gibbons. But the disadvantages of using the pseudo-curvature—we have already

SUBTABLE III. *Table of Indices of Bowing and Femoral Curvature*[1].

Race	Individuals	Primary Index of Bowing		Secondary Index of Bowing		Pseudo-curvature in cm.$^{-1}$		Pilaster
Primogenial Man (Cromagnon Type)	Cromagnon	4·08	4·25	41·5	43·1	·0118 (1)	·0127	Exaggerated
	Tilbury	4·43		44·7		·0137 (1)		
Primogenial Man (Neanderthal Type)	Neanderthal	4·19	3·69	58·2	53·45	·0132 (1)	·0122	Slight
	Spy	4·14		48·9		·0138 (1)		
	Homo mousteriensis (*Hauseri*)	3·84		54·2		·0151 (1)		
	La Chapelle-aux-Saints	2·58		52·5		·0069 (1)		
Pithecanthropus erectus	... ...	2·82?	2·82?	48·7?	48·7?	·0081? (1)	·0081?	Present
Anthropoids (i)	Gorilla (5)	2·91	2·75	50·2	49·3	·0136 (33)	·0125	Absent
	Chimpanzee (1) ...	2·67		40·8		·0128 (20)		
	Orang (1)	2·66		49·8		·0082 (5)		
Galley Hill ...	... ...	2·67	2·67	67·1	67·1	·0081 (1)	·0081	Well-marked
Recent Man ...	17th century Londoners ♂ (476)	2·55	2·53	36·85	39·0	·0096 (476)	·0096	Well-marked
	17th century Londoners ♀ (361)	2·50		41·13		·0097 (361)		
Anthropoids (ii)	Gibbon (1)	0·51	0·51	62·6	62·6	·0052 (16)	·0052	Slight

commented on the disadvantages of this and Antony and Rivet's radius of curvature: see our pp. 276—9—are clear on examination of this column. Instead of a marked difference in bowing between the Neanderthal and Cromagnon Types, we find a near equality in the pseudo-curvature, while the larger anthropoids have a greater pseudo-curvature than primogenial man with far less bowing. The simple explanation of these anomalies is that if we magnify a femur n times, we obviously do not alter the amount of its bowing, we are merely modifying the scale on which we choose to examine it, but we increase its pseudo-radius of curvature n times and decrease its pseudo-curvature to $1/n$th of its previous value. Hence as the Cromagnon Type is

posterior face of the bone may have learnt a new habit, but they are not germ cells, and the vigorous language of Adami (*Medical Contributions to the Study of Evolution*, London, 1918; especially pp. 132—160) does not help us to ascertain how they are going to modify the germ cells. Darwin's theory of pangenesis would do so, but since Galton's crucial experiments on transfusion (*R. S. Proc.*, Vol. XIX. pp. 393—410) cast discredit on the blood as the bearer of the gemmules it is very difficult to accept that theory. The appearance of a new factor leading in some manner to the dwindling of an older and closely associated factor suggests a more hopeful path of inquiry and transfers the problem from gross to cytological mechanics.

[1] The anthropoid femora available when this table was constructed were those of the folding table, Table I, p. 450 of this chapter, not those of the complete table of the Atlas, Part II, summarised in folding Table III of this chapter.

absolutely larger than the Neanderthal Type, and that type larger than that of the greater anthropoids, erroneous conclusions must be drawn when curvature is used as a measure of bowing, and this will be quite apart from the error introduced by the fact that the curvature of the diaphysial arc is far from constant. If we confine our attention to the Primary Index of Bowing, the bowing increases from Greater Anthropoids to Neanderthal Type and still more to Cromagnon Type, but it falls in Recent Man. This is precisely the case also with the pilaster, the series being: absent, slight, exaggerated and then a fall to well-marked. In pilaster Recent Man is nearer to the gibbon and some of the lesser apes than to the Greater Anthropoids. In shape of pilastric section we pass from maliform (Greater Anthropoids) to rotiform (Neanderthal Type), to pyriform (Cromagnon Type), while Recent Man has a less exaggerated pyriform section and frequently tends to more rotundity. In Bowing *Pithecanthropus erectus* is simply human if we can trust our queried value. Bowing gives no confirmation of the *Hylobates giganteus* theory, for the Gibbon[1], judged by the Primary Index or by the Pseudo-curvature, is widely divergent from man in any form. In both Bowing and Pilaster Galley Hill appears to stand nearer Recent Man than to Neanderthal Man. If our values for the indices be, however, correct, Galley Hill is more bowed than La Chapelle-aux-Saints. A curious point about Galley Hill is the low position as judged by the Secondary Index of Bowing of the point of maximum bowing, it is almost at the distal third point of the Diaphysial chord. About the proximal third point, however, the anterior face of the Galley Hill shaft is somewhat broken away. We very carefully plotted point by point the anterior face from the cast, and it seems to us that in the neighbourhood of the proximal third point there are signs of contra-flexure apart from the defective area, and this tends to support the view that the feebleness of the shaft in this neighbourhood is not natural but due to post-mortem injury, or ante-mortem pathological condition. The point of maximum bowing is about the middle of the shaft for the *larger* anthropoids (a little above the distal third point in our specimens of gibbon!); it falls just below the midpoint of the shaft in Neanderthal Man, but rises markedly in Cromagnon Man, and reaches the $\frac{2}{5}$ths point in Recent Man. To grasp the significance of these changes would need far fuller data than we yet possess, and a far more comprehensive study, leading to a clearer knowledge, of the functional services of bowing in the femur. Our table, however, suffices to indicate that Bowing can hardly be looked upon as an anomaly; it is a racial character, which has been developed as any other racial character, in the evolutionary process, and may, as knowledge increases, be an important element in determining the evolutionary order.

We have seen (p. 283) that Bowing is intraracially significantly, if not very markedly, correlated with the Pilastric Index. Interracially we failed on p. 282 to find any association between Pilastric Index and Curvature. If we arrange our present material in order of Pilastric Index we have:

[1] *Dryopithecus rhenanus* with Primary Index 0·6 is what we should anticipate in *Hylobates giganteus* —*i.e.* scarcely any bowing.

SUBTABLE IV. *Index of Bowing and Pilastric Index.*

Race	Individuals	Pilastric Index		Primary Index of Bowing	
Primogenial Man (Cromagnon Type)	Cromagnon	125·2	125·1	4·08	4·25
	Tilbury	125·0		4·43	
Primogenial Man (Neanderthal Type)	La Chapelle-aux-Saints ...	117·9		2·58	
	Spy	107·7	108·1	4·14	3·69
	Homo mousteriensis (*Hauseri*)	104·6		3·84	
	Neanderthal	102·3		4·19	
Pithecanthropus erectus	... ...	108·7	108·7	2·82?	2·82?
Recent Man	17th century Londoners ♂ ...	104·4	103·0	2·55	2·53
	,, ,, ♀ ...	101·6		2·50	
Galley Hill	... ...	99·2	99·2	2·67	2·67
Anthropoids (ii)	Gibbon	95·0	95·0	0·51	0·51
Anthropoids (i)	Chimpanzee	84·3		2·67	
	Orang-utan	80·0	80·4	2·66	2·77
	Gorilla	77·1		2·91	

It will be clear that our failure to find a relation between Pilastric Index and Bowing was not solely due to the use of curvature (p. 282). It was of course partly due to the curvature displacement of Gorilla. But when we use the Index of Bowing we still find that the Greater Anthropoids do not fit into the series. *Hylobates*, Recent Man, Neanderthal Man, Cromagnon Man, form a series in which the Pilastric Index and the Index of Bowing both ascend, and interracially there is high correlation of Pilastric and Bowing Indices[1]. This result seems to indicate that at any rate in Man and the Lesser Apes there is a close association between Bowing and the development of a high Pilastric Index. But we must not extend the principle to the Greater Anthropoids for with a low Pilastric Index they have more Bowing than Recent Man. We see, however, the weakness of the Pilastric Index as a measure of the pilaster, for the common order of the two indices is not the order of pilaster development. It gives

Cromagnon Type	125·1	Pilaster exaggerated
Neanderthal Type	108·1	,, slight
Recent Man	103·0	,, well-marked
Hylobates	95·0	,, slight
Greater Anthropoids	80·4	,, absent.

The fact is as we have indicated on p. 255, the Pilastric Index does not distinguish between rotiform sections like those of the Neanderthal Type and pyriform like those of Recent Man, if their antero-posterior and transverse diameters are nearly equal.

If we want to pass from the slightly maliform pilastric section of the gibbons or the almost perfectly rotiform section of many of the *Cynopithecidae* to Recent Man, we have got to increase the Pilastric Index and also develop the pilaster from slight to well-marked. The pilaster remained slight in Neanderthal Man, but the Pilastric Index was raised; in Cromagnon Man the Pilastric Index was still further raised and an exaggerated pilaster developed—the pilastric section was markedly pyriform. Recent

[1] Of order ·89 ± ·26.

Man has fallen closer to the Lesser Apes in Pilastric Index, but has retained the pilaster in a well-marked, if not exaggerated form. In other words the pilastric section has remained pyriform, but the transverse pilastric diameter has somewhat increased, relative to the antero-posterior. It is quite possible to hold that both Primogenial men of the Neanderthal and of the Cromagnon Types are side branches and not on the direct line to Recent Man, as we may still more reasonably suppose the Greater Anthropoids to be. But somewhere on the direct line individuals must have existed with pilastric index increased beyond that of the Lesser Apes and with well-marked pilasters, as the branching points from which Neanderthal and Cromagnon Man sprang off. These individuals have yet to be found. Those who would place the Trinil Femur in the direct line of Man's ascent certainly get over the difficulty of explaining how Recent Man has developed a high Pilastric Index and a pilaster. They seem, however, to forget that it will be needful then to account for the development on side tracks of Neanderthal and Cromagnon Man from *Pithecanthropus erectus*. The task presents no smaller difficulties than supposing Primogenial Man a stage towards Recent Man[1].

To sum up the conclusion suggested by this discussion of the anomalies of the femur in the case of Man, we may state that the anomalies which occur occasionally in Recent Man are to a great extent signs of a far grosser and more muscular member. Such a femur exists in the case of both the Greater Anthropoids and of Neanderthal Man, but the anomalies we refer to are almost usual in the latter, and such a marked feature of the former as the complete *fossa angulolateralis* has never yet been found even as an occasional anomaly in Man. On the other hand the well-marked pilaster is found neither in the Greater Anthropoids nor in Neanderthal Man. It is found in Cromagnon Man and in an exaggerated form. In a slighter form it is found in the Gibbon and in some of the Lesser Apes. If we suppose the direct human descent, as seems highly probable, never to have passed through any of the Greater Anthropoids as we know them but to pass directly to some simio-human form somewhat more akin to the lesser apes, we ask, are the Neanderthal and Cromagnon Types to be considered as branching failures from the main line of descent or as actual stages upon it? If the former we leave unexplained the occurrence of anomalies in Recent Man which point to an extremely muscular ancestry. We are almost bound to insert something very like the Neanderthal and Cromagnon Types in the direct line to account for the appearance of these anomalies, for the marked bowing and the well-marked pilaster of Recent Man. If we insert these links into the main line, the Neanderthal and Cromagnon Types will differ somewhat from them, but not very widely, and therein lies,

[1] Verneau (Bibl. 94 *quater*, p. 316) states that the races of Spy and Grimaldi are parallels derived from *Pithecanthropus erectus*. If this view were correct the femur of man was completely developed while his cranium remained most primitive; then followed a development in which many of the femoral features of Recent Man disappeared in the Spy parallel. Did Recent Man recover them as a descendant of the Neanderthal Type or would Verneau suppose him a third parallel from *Pithecanthropus erectus*, which retained nearly all the characteristics of the femur, but widely modified the cranium? The dilemma might, perhaps, be solved by separating Trinil femur and cranium.

as far as the Neanderthal Type is concerned, the justification, if any, for Schwalbe's view that the discussion of whether the Neanderthal Type (and we might add the Cromagnon Type) is or is not in the direct line is not of much worth. As far as the anomalies of the femur of Recent Man go, if Neanderthal and Cromagnon are not in the direct line, we have still got to insert some links very like them between the Prot-simio-human with a probable lesser apelike and lemuroid ancestry and Recent Man, and then those links remain yet to be discovered.

Klaatsch, possibly carried away by the differences he observed between two individual cases of Mousterian Man and Aurigniac Man, has postulated a double ancestry for man, a "gorilloid" and an "orangoid" origin. It is not very clear from his writings on the subject[1] whether he supposes Primogenial Man of the Neanderthal Type to be descended from a gorilla and of the Aurigniac Type from an orang. If we put his view, not in the form of ancestry, but in the form of a resemblance, the femur of the Neanderthal Type is to the femur of Recent Man as the femur of the gorilla is to the femur of the orang, or again we might add as the femur of the Pekinese Spaniel to that of a Pommeranian dog, there appears somewhat more truth in the proposition[2], at least ocularly. But when we come to the detailed numerical study of the femoral characteristics as in our last chapter, we find so many cases in which Recent Man actually separates both of these anthropoids from man of the Neanderthal Type that our faith in the suggestiveness of the proportion, and with it the strength of the argument for side tracking of the Neanderthal Type, are very much weakened. The reader should bear this point in mind in the summary of the results of that chapter as far as concerns Primogenial and Recent Man that we have now to place before him.

(iii) *Comparison of quantitatively Measured Characters in the Apes, Primogenial Man and Recent Man.*

(*a*) *General Remarks.* In dealing with this topic it seems by far the wiser course to group the anthropoids as far as possible together, to cite merely the means of our slender data for Neanderthal and Cromagnon Types and to represent Recent Man in the main by our 17th century Londoners; for in that case only have we adequacy of material for *all* the characters we propose to consider.

Before we enter into a full discussion of our topic, it is desirable to investigate in such detail as is at present possible the relations between Recent Man, Verneau's Grimaldi Negroid Type and the Cromagnon Type as far as the femur is concerned. The accompanying table places in parallel columns the characters of the Cromagnon Type, of Recent Man as represented by our 17th century London bones, the Grimaldi Negroid Type and the Modern Negro. The reader must not for a moment be over impressed by the apparent weightiness of the numerical data here assembled. The columns of Recent Man are alone based on unity of method, adequacy of material and

[1] Bibl. 102 *bis*, and Bibl. 102 *ter*.

[2] There are a good many species where the double type occurs, and without taking refuge in achondroplasia and pathological causes, it may be that physiology will ultimately throw light on the not uncommon appearance of the double type.

TABLE I. *Measurements of the Femora of Primogenial Man and Comparatives.*

Character	Apes								*Pithecanthropus erectus*	Primogenial Man								Modern Man
										Type A				Type B		Type C_1	Type C_2	
	Gorilla		Chimpanzee		Orang-utan		Gibbon			Neander-thal	Spy	*Homo Mousteriensis (Hauseri)*	La Chapelle aux Saintes	Cromag-non	Tilbury	Galley Hill	*Homo [illegible] (Hauseri)*	17th century Londoners
Number	authors' 5	others + authors'	authors' 17	others + authors'	authors' 15	others + authors'	authors' 19	others + authors'	L. 1 (from photographs and Dubois)	L. 1 (from cast)	R. 1 (from cast)	L. 1 (from cast)	R. 1 (from photographs)	1 (from cast)	1 (from cast)	L. 1 (from cast)	R. + L. 2 (Klaatsch and photographs)	283 to 487 ♂ (R. + L.), 197 to 381 ♀ (R. + L.)
Sex	♂ ♀ ♀																	
Major Lengths																		
Maximum Length ...	514·0	454·2 (21)	438	398·1 (9)	413	365·2 (5)	203·8		433	445·5	429·5	484	450·5	—	—	424·0	425	441·24 to 499·49
Trochanteric Length ...	440·1		380		225		202·2		437	420	417	472·?	411				410	423·81 to 489·40
Maximum Troch. Length ...	448·4		414		233		203·2		450	435	425	475·5?	415				416	434·60 to 507·?
Oblique Length ...	441·0	392·8 (20)	411	359·4 (14)	241·5	205·2 (5)	205	204·? (5)	432	444	428·5	477·?	429	401	400	425·1	423	444·02 to 505·52
Trochanteric Oblique Length ...	440·1	390·1 (4)	412	362·0 (3)	228·2	241·1 (5)	202·1		432	420	415	472·?	409·5				406·0	423·56 to 485·71
Capito-trochlear Length ...	501·0		464·5		236		209·3		441	425	391	456·0	402·6				405·2	438·0 to 511·01
Diaphysial Length ...	485·8		438		238·5		211·9		394	380	356	415·0	366	366	358·?	406·4	[illegible]	[illegible]
Length of Shaft ...	429·5		407·5		264		184		395	386	364	424·3	369		—	382·2	408	400·00 to 514·4
Bust																		
Vertical Diameter of Head ...	47·3	47·0 (3)	45·0	44·? (1)	29·?	24·? (3)	15·9	17·0 (3)	48·0	54·0	55·8	47·7	51·0	—	—	44·2	44	47·01 to 49·04
Horizontal Diameter of Head ...	47·?		43·0		29·2	—	15·9		44·0	52·8	53·0	47·4	50·4				44	47·43 to 49·00
Min. Horiz. Diameter of Neck ...	25·8		24·1		14·0		8·2			28·1	32·4	32·5	33·0			24·0	24	25·?8 to 27·07
Min. Vertical Diameter of Neck ...	32·?		22·?		14·8		11·1		28·0	38·2	39·31	33·2	—				31	34·43 to 37·43
Capito-iliac Length ...	80·5		65·0		43·?		29·5		74·0	69·5	70·2	67·0	82·5			— 2	66·0	72·12 to 78·?
Length of Neck ...	56·0		45·1		29·0		21·0		51·5	37·8	48·3	43·2	50·?			41·0	48·8	41·42 to 51·42
Shaft																		
Proximal Breadth ...	91·?		77·0		57·5		30·5		82·0	104·?	112·0	92·4	99			100·1	86	
Platymeric A.P. Diameter ...	27·8	29·0 (4)	24·0	26·0 (1)	15·2	14·1 (3)	9·3	10·8 (3)	31·2	26·5	26·9	24·7	28·0	30·2	29·2	—	25·3	27·4 to 29·48
Platymeric Trans. Diameter ...	31·0	31·0 (4)	26·0	27·1 (4)	20·1	17·5 (3)	10·0	12·3 (3)	33·2	30·2	31·2	30·3	33·?	30·?	32·2	29	31·00	30·? to 33·?
Pilastric A.P. Diameter ...	28·0	27·2 (4)	23·2	21·? (3)	14·1	13·? (3)	9·0	10·1 (3)	29·0	31·1	32·1	25·?	30·0 (34)*	32·?	30·2	25·?	24·11	27·? to 29·1
Pilastric Trans. Diameter ...	31·1	30·0 (4)	25·2	26·? (4)	14·2	13·? (3)	9·2	11·2 (3)	32·?	30·8	30·0	25·0	28·0 (29)*	33·?	28·0	29·1	25·?	27·00 to 29·?
Popliteal Length ...	136·1		112		67·?		41·1		130·0	110·0	110·0	128·5	108·??			111·3		121·1 to 135·1
Popliteal Width ...	48·2	46·1 (4)	40·?	40·2 (3)	28·0	25·? (3)	11·0	12·8 (3)	46·0	40·0	42·0	41·5	40·0	41·?	43	41·8	44	39·? to 43·?
Popliteal Direct A.P. Diameter ...	27·?	26·0 (4)	22·2	21·? (3)	16·?	15·? (3)	8·0	10·3 (3)	32·0	33·1	35·5	26·0	30·0	47·5	40·0	31·0		27·? to 29·1
Popliteal Oblique A.P. Diameter ...	29·3	30·1 (4)	24·2	24·? (3)	17·1	14·? (3)	8·0	10·3 (3)	30·0	28·5	33·0	26·5		36·0	40·?	29		30·00 to 32·?
Diaphysial Chord ...	130·4		109·0		73·0		49·0		125·0	105·0	105·4	96·0	110	115·?	107·?	96·0		112·00 to 122·?
Diaphysial Subtense ...	5·52		4·?		2·?		1·?		5	10·6	12	7·8	6·1	11·2	11·4	7·0		7·49 to 8·?
Proximal Segment of Diaphysial Chord ...	98·?		84·2		59·2		39·2		134·8	114·5	110·1	110·1	124	113·9	113·0	103·5		110·? to 121·0
Condyles																		
Bicondylar Width ...	84·1	88·2 (4)	69·5	69·2 (4)	47·1	55·? (3)	29·5	30·0 (3)	86·0	80·0	94·0	83·3	84·0?			88·0	85	86·00 to 92·?
Max. Length Ext. Condyle ...	51·5		42·5		36·2		18·?		62·2	55·2	73·?	70·1	[70·1]†			64·0		62·14 to 67·0
Max. Length Internal Condyle ...	52·?		50·?		34·4		19·9		64·?	60·5	69·1	66·0	64·?					62·? to 66·?
Oblique Length External Condyle ...	50·4		46·0		31·?		17·?		62·0	54·2	52·2	58·0				46·0		54·? to 55·?
External Condyle Ant. Hand Radius ...	22·1		20·1		20·?		9·0		20·0	25·2	28·0							18·? to 20·81
External Condyle, Vert. Hand Radius ...	21·?		19·1		12·?		8·6		23·4	24·8	27·7?	—						20·82 to 23·48
Angles																		
Metatrochanteric Angle ...	25·1		21·?		17·0		5		5	7·5	10·0	10·6	11·0			8·0	8·5	9·?
Angular Centre of Head ...	35·1		31·?		25·0		22·?		48	49·?	58·0	51·5				47·?	48·5	44·?
Collum Angle ...	117·4	110·8 (22)	114·5	112·0 (5)	104·0	105·2 (10)	117·0	123·9 (24)	124·0	125·5	112·0	112·5	112·0			127·?	123·?	124·? to 127·?
Torsion of Shaft ...	12·?		12·?		5·0		5			22·0	18·0	10·0	—			23·?	24·?	21·? to 23·?
Torsional Angle ...	9·?	7·4 (19)	6·5	5·0 (23)	4·0	4·1 (5)	9·0	8·4 (24)	15·0	6·0	16·0	8·5				13·0	13·?	14·? to 16·43
Retrotorsional Angle ...	12·?		11·5		12·?		4·5		—	16·0	22·0	18·5				14·0	11·?	11·? to 13·?
Obliquity of Shaft ...	2·4		2·?		1·0		4·0		12	5°·5	5·0	1·0	3°·0			3·?	10·15	10·? to 11·61
Pseudo-Obliquity ...	0·0	0°·0 (20)	0·?	8·0 (11)	6·4	0°·0 (5)	0·0		0·0	0·1	3°·9	10°·9·	4°·8			5·?	5·??	5·81 to 7·42
General Indices																		
Oblique-Direct Lengths Index ...	100·0	100·0 (21)	99·0	98·8 (11)	99·4	100·0 (5)	100·0		99·3	99·4	99·8	98·2	99·?	—		99·8	98·5	99·? to 99·?
Oblique Direct Troch. Lengths Index ...	100·0		100·0		100·1		100·0		98·9	100·0	99·5	100·0?	99·6				99·2	99·49 to 99·?
Proximal Breadth Ratio ...	26·8		25·0		25·1		15·1		21·1	24·6	26·0	24·8?	24·1			24·0	24·0	
Distal Breadth Ratio ...	24·3	24·1 (4)	22·4		24·2		12·6		17·8	21·0	22·4	22·4?	20·4			21·?	18·?	18·? to 18·43
Robusticity of Femur ...	18·2	18·2 (19)	15·2	16·1 (24)	14·3	15·3 (9)	9·2	10·8 (24)	12·7	14·0	14·0	14·5?	14·8	14·4	15·8	12·4	12·6	12·84 to 12·52
Bust Indices																		
Robusticity of Head ...	20·8	21·0 (18)	23·1	22·0 (4)	24·2	21·1 (5)	15·0	10·8 (24)	19·7	24·1	25·0	25·2	24·8			23·?	19·1	21·02 to 20·1?
Ellipticity of Head ...	100·0		100·0	99·0 (4·5)	99·?	93·5 (5)	100·0		97·8	97·8	98·0	99·4	97·8				104·?	98·86 to 99·10
Ellipticity of Neck ...	78·0	75·5 (21)	70·3	75·5 (11)	58·?	76·2 (5)	73·9		?	73·0	82·0	97·9				69·0	82	75·09 to 76·92
Secondary Index of Neck ...	99·3		98·?		47·9		51·9		?	53·2	58·9	68·0	—			50·?	55·5	55·28 to 53·34
Head-Bust Ratio ...	57·9		57·0		64·4		53·9		60·8	63·?	73·2	71·2	62·5		—	68·?	59·4	61·32 to 60·70
Primary Bust Ratio ...	23·0		20·1		18·?		14·5		16·3	14·3	17·?	17·4	19·2		—	17·?	19·2	17·24 to 16·66
Secondary Bust Ratio ...	23·4	22·0 (16)	20·3	18·9 (25)	18·8	20·? (6)	14·5	13·6 (24)	16·4	14·8	17·9	17·9	19·2			17·?	16·3	17·35 to 16·8
Bust-Shaft Index ...	28·3		24·5	-	22·?		16·0		18·7	16·?	20·9	20·7	22·1	—		19·9	18·8	20·48 to 19·92
Capital Ratio	14·1	13·5 (1)	11·4	11·8 (4)	12·1	12·8 (5)	7·8		9·80	12·1	13·0	12·4	12·0	—	—	11·0	9·6	10·49 to 10·03
Capito-bicondylar Index ...	55·1	53·0 (1)	51·?	53·1 (3)	56·2	59·3 (3)	62·4	58·? (3)	57·7	60·3	59·6	57·3	61·4?			[55·0 ?]	54·?	59·02 to 58·22
Epiphysial Ratio	98·1		90·0	-	87·3	-	115		94·9	72·0	81·4	80·4	98·2?			[82·0 ?]	92·0	96·88 to 96·22
Shaft Indices																		
Platymeric Index	84·0	81·4 (18)	83·1	82·1 (27)	91·1	71·4 (8)	87·2	83·4 (26)	94·0?	73·2	74·3	77·?	85·1	84·?	81·4	90·?	80·4	85·22 to 82·87
Pilastric Index ...	85·2	84·1 (18)	86·1	84·5 (9)	80·2	85·0 (1.)	104·3	95·0 (30)	108·?	102·3	107·?	104·6	117·9 (100·9)*	125·2	125·0	99·2	114·0	104·43 to 101·61
Pophteal Index ...	85·3	85·4 (11)	87·2	90·1 (5)	61·3	62·? (8)	74·8	82·1 (7)	88·9	81·5	82·8	69·9	83·3?	90·4?	87·0	86·2		76·84 to 67·02
Index of Popliteal Skewness ...	70·1	[illegible]	65·9	101·?? (3)	90·1	93·4 (3)	100·0	97·2 (3)		110·1	104·7	109·4	—	96·2?	98·4?	105·1		96·96 to 90·57
Popliteal Pyramidal Index ...	54·3		57·2	—	30·?		13·1		24·0	36·9	39·0	32·3	33·3?	—		30·4		33·05 to 32·83
Soleal Index ...	55·2	50·? (2)	49·0	44·1 (4)	51·1	49·0 (3)	46·2	42·8 (3)	40·2	45·3	45·8	49·8?	42·9?			50·0 ?	45·3	49·09 to 50·86
Index of Gracility (Upper) ...	99·0	100·0 (1)	100·?	98·9 (3)	93·?	90·8 (3)	84·4	91·0 (3)	84·1	85·1	82·9	78·4	83·3	80·0	87·0	73·0	84·?	88·83 to 88·01
Index of Gracility (Lower) ...	70·?	83·2 (10)	75·0	77·0 (3)	72·2	73·? (3)	77·3	84·8 (6)	76·?	75·9	69·9	57·6	77·8	81·2?	81·2?	58·9	72·?	71·04 to 70·75
Index of Transverse Slenderness ...	11·7		10·2		6·6		5·0		9·09	7·08	8·24	7·37	7·60			7·29	6·79	7·43 to 7·27
Index of Sagittal Slenderness ...	9·85		8·2		7·7		5·2		7·59	8·16	8·87	7·71	8·94	—	—	7·20	7·24	7·71 to 7·35
Index of Proximal Taper ...	100·5	100·8 (5)	104·0	98·? (4)	98·?	98·8 (3)	99·0	100·9 (3)	104·0?	81·1	84·3	94·8	86·6	88·?	74·9	90·8	89·5	91·92 to 92·12
Index of Distal Taper ...	89·9	91·0 (9)	109·1	100·0 (1.)	105·8	100·0 (9)	92·?	90·0 (7)	100·?	105·1	100·9	116·0	90·9	88·9?	85·7?	118·3		95·97 to 95·98
Popliteal Shaft Index ...	48·1	—	49·3		43·1		49·5		38·0	28·5	30·2	39·6	29·3??	—	—	19·?	—	32·28 to 31·99
Primary Index of Bowing ...	2·91		2·6	-	2·00		0·51		2·82	4·19	4·14	3·84	2·58	4·08	4·43	2·67		2·55 to 2·50
Secondary Index of Bowing ...	50·2		40·8		49·8	-	62·9		48·7	58·2	48·9	54·2	52·5	41·5	44·?	37·1	—	36·85 to 41·13
Condylar Indices																		
Condylar Index ...	61·1	—	64·2		67·6		68		79·7	83·9	78·7	84·5?	[84·2]†	—	—			78·08 to 79·91
Condylar Lengths Index ...	81·?	83·? (1)	84·5	79·? (3)	85·0	81·0 (5)	92·0	90·9 (4)	95·2	108·2	100·?	117·3?	[110·5]†	—	—			100·34 to 100·80
Bandrethal Index ...	97·7		95·0	92·5 (2)	90·0	79·9 (5)	95·0	91·3 (2)	112·0??	98·4??	98·9??	—	—	—	—			111·94 to 110·78
Bicondylar Ratio ...	24·4	24·? (7)	22·1	21·3 (3)	24·4	22·1 (3)	12·5	11·7 (3)	17·4	20·1	21·8	21·7?	19·5	—	—	[20·8 ?]	19·6	17·83 to 17·25
Condylar Troch. Index ...	14·8	—	12·9		15·2	—	8·8	-	[illegible]	[illegible]	[illegible]	[illegible]	[17·2]†	—				14·07 to 14·18

* Values given by Boule. † Reconstructed

ERRATA

In column 2 *for* 80·8 (5) *read* 80·8 (4)

9	17·8	14·2
10	21·0	17
11	22·4	17·7
„ 12	22·4?	„ 18·9?
„ 18	[383]	378·1
19	[351]	347·0

„ 17 . Homo Aurignensis *read* Homo Aurignacensis

sameness of sample. In the case of the other races none of these *desiderata* are forthcoming. For the Cromagnon Type we have based our characters on the Cromagnon and Tilbury casts and on the six femora discussed by Verneau. The measurements he gives are few in number and we have had to obtain the bulk of those now provided from the illustrations he gives of two of them[1]. It will therefore be seen that our mean values for the Cromagnon Type are drawn from any number up to eight. Thus very frequently there will be considerable divergence between the mean index and the index of the means. As Verneau provides only the anterior and posterior aspects of his selected femora, we have been unable to determine antero-posterior dimensions (except where he states them) on any femora beyond the original Cromagnon and the Tilbury femora. Verneau's six femora are given as male and that seems highly probable. We consider the original Cromagnon as certainly male and the Tilbury as doubtful. We have assumed it male for the purpose of averaging. This leaves us without a single representative of the Cromagnon woman. This is a great disadvantage as the Grimaldi Negroid Type is represented only by an "Old Woman" and an "Adolescent." We have therefore been compelled to reconstruct a Cromagnon female femur for the purposes of comparison. For the absolute measurements we have used sex factors ; for the indices we have used a mixed method giving consideration to all sorts of hints, which depend upon the individual measurements concerned and the experience of the sexual relationships gained from our tables of special characters[2]. Notwithstanding these difficulties we think that this reconstruction of the Cromagnon woman is a moderately satisfactory one. While we have only worked with a maximum of eight and often with only two femora Rodriguez[3] appears to have used 13 for the characters tabled by him.

The following summary indicates our agreements and our divergences (he gives all as males) :

	Rodriguez (13)	Pearson and Bell (2 to 8)
Oblique Length	499	519
Robusticity of Femur ...	12·3	13·0
Robusticity of Head ...	21·8	21·5
Pilastric Index	111·6	125·1
Platymeric Index	72·2	73·0
Ellipticity of Head	100·0	99·3
Secondary Bust Ratio ...	17·0	16·4
Collar Angle	126°·0	126°·0

On the whole there is not more disagreement than might be anticipated in two samples of such different sizes. The chief differences are in the absolute lengths. Ours are the bigger and more massive specimens, and this will possibly account for

[1] The process of measuring illustrations is always risky and arduous. The stated scale (*e.g.* $\frac{1}{2}$ or $\frac{1}{3}$ natural length) is in our experience never accurate and reducing factors have to be determined to make the illustrations accord with the published measurements. Further it is rarely that the femur has been fairly adjusted before photography to the standard planes, and allowance has frequently to be made for this.

[2] We could not deduce all the indices from the absolute measurements, because even in the male case the means are not always deduced from the same individuals.

[3] Bibl. 101, p. 11.

all but the Pilastric Index divergence. Unfortunately Verneau does not provide the pilastric dimensions of any of his femora and we have only been able to obtain the transverse diameters on those he has photographed. For the Grimaldi Negroid Type we depend entirely on Verneau's few measurements and on his plates[1]. A serious difficulty in the case of the modern Negro arises from the fact that no adequate study has hitherto been made of his femur. Further the "Modern Negro" is no more than the "Modern White" a single race. There are as many distinct races of Negroes as of Whites and the simple labelling of skeletons as "Negro" is much to be reprehended. We have been compelled, however, to maintain this general term as our material has had to be collected from many sources. All we can say is that we have given due consideration to each character[2] and it is the best reconstruction of the "Modern Negro" we have been able to provide from the data available. It is admittedly of a temporary character, but will, perhaps, suffice to bring out the points we desire to emphasise.

A word may be said here about the measurement of the distal articulation. It will be remembered that this character is given by Parsons for his Rothwell English and by Tamagnini and de Campos for their Portuguese femora instead of the Bicondylar Width. Its ratio to the maximum length we term the Distal Articulation Ratio. The following results show that it is nearly constant for recent Europeans *if measured in the same manner*:

	Rothwell English	Portuguese
♂	16·74	16·77
♀	16·13	16·13

Accordingly there would appear little doubt that for our 17th century Londoners if the Distal Articulation had been measured in Parsons' manner we ought to have found:

♂ 74·9 ♀ 66·0

From these we should have obtained a "Distal Articulation Index" = 100 Distal Articulation/Bicondylar Width, for our material represented by

♂ 93·9 ♀ 94·3

or the Distal Articulation might be found from the Bicondylar Width by multiplying by the factor ·94 *in the case of mean values.*

Actually we did not obtain these values but the following:

		♂	♀
Distal Articulation Breadth	...	70·22	62·25
Distal Articulation Ratio	...	15·76	15·29
Distal Articulation Index	...	89·57	88·53

[1] Rodriguez also gives four characters for the *Fossile Race Négroïde de Grimaldi*, for which he gives the number of femora as *three*. His measurements are for *female* only: Oblique Length, 434; Robusticity of Head, 20·1; Platymeric Index, 81·8; Index of Head, 102·8. These appear to agree closely with the measurements of the "Old Woman"—*i.e.* would be for a *single* femur. If he actually handled three femora, it is surprising that he has not given us other measurements.

[2] Where the indices provided are the same for ♂ and ♀ it is because our sources provided no sex distinction. The numbers used for each character run from 8 to 100, and are therefore of very different weight.

Now we did not take the distal articulation in Parsons' manner, for it appeared to us very unsatisfactory especially in the case of the Lemuroids and Apes. We took as will be explained later in this Chapter the maximum breadth of the distal articulation. That this should give a result 3 to 4 mm. *less* than that obtained above is to us inexplicable, unless the agreement between Rothwell English and Portuguese for the Distal Articulation Ratio be merely fortuitous.

Unfortunately we do not know how Verneau has measured his distal articulation breadths. Assuming his method to have been like that of Parsons' we must place for comparison in the accompanying table not our actual measurements but those deduced by supposing the Rothwell English Distal Articulation Ratio to apply to all Europeans. Such are the values given in the accompanying table, under 17th century Londoners, but their enclosure in square brackets signifies that they depend on a special hypothesis.

(*b*) *Cromagnon and Recent Man.* We shall now proceed to a comparison of the four types displayed in the table. Let us examine first the Cromagnon Type and that of Recent Man. The Cromagnon Type as compared with the Greater Anthropoids or with the Neanderthal Type shows great increase of size, exaggerated pilaster, exaggerated torsion and exaggerated bowing. Most of these characters were probably advantages from the standpoint of survival, as emphasising uprightness of position and rapidity of movement, but to judge by Recent Man they were over accentuated. The great size was reduced, but Recent Man remained sensibly taller than the Anthropoids or Neanderthal Man. Now let us consider what this reduction in size means. Cromagnon Man is about 20 per cent. larger in femur than Recent Man as represented by our Londoners. The factors by which we must multiply our London male to obtain our Cromagnon male are: Maximum Length, 1·200; Trochanteric Length, 1·203; Proximal Breadth, 1·209; Shaft Length, 1·215. Now suppose we reduced the Cromagnon Type femur in this manner, how would it compare with that of Recent Man? In the first place we should have over-reduced the V. Diameter of Head (1·164), the Length of Neck (1·065), the Capito-collar or Bust Length (1·113), the Bicondylar Width (1·162) and the Distal Articulation (1·121), the reducing factors of which are given in the brackets. In other words the gain in size of the epiphyses was to a very considerable extent maintained. It may be asked why, if the epiphyses maintain so much of the Cromagnon size, this is not shown in the Proximal Breadth? This very heterogeneous measurement is influenced not only by the breadth of the great trochanter, but still more by the size of the Collar Angle, and this has had a very sensible increment and therefore provides *ipso facto* a lessening of the Proximal Breadth.

Now let us look at the cross-dimensions of the shaft. The Platymeric Antero-posterior Diameter (1·074) remains much larger; the Pilastric Antero-posterior (1·326) and Popliteal Antero-posterior (1·311) Diameters have decreased relatively. The Platymeric Transverse Diameter (1·250) has somewhat decreased, but the Pilastric Transverse (1·071) and the Popliteal Width (1·149) have remained larger. These facts are exactly mirrored in the corresponding indices, the Pilastric Index and the Popliteal Index have markedly decreased while the Platymeric Index has increased. In other words Recent Man has lost something of the exaggerated pilastry and

TABLE II. *Cromagnon and Verneau's "Grimaldi Negroid" Types compared with Recent White and Negro Races.*

Character	Cromagnon Type		Recent Man 17th century Londoners		"Grimaldi Negroid" Type		Modern Negro	
Sex: Age:	♂ Adult	Probable ♀ Adult	♂ Adult	♀ Adult	♀ Old	♂ Adolescent	♂ Adult	♀ Adult
Maximum Length	528·3 (5)	483·4	447·2	409·2	436	421	[451·7]	[415·7]
Trochanteric Length	511 (2)	467	425·8	389·1	426	392	—	—
Maximum Trochanteric Length	523 (2)	479	434·6	397·8	430	399	—	—
Oblique Length	518·8 (5)	473	444·9	405·8	434	419	449·4	412·4
Trochanteric Oblique Length ...	504 (2)	459	423·5	385·7	423	391	—	—
Capito-trochlear Length ...	512·5 (2)	467	432·3	394·0	425	410	—	—
Length of Shaft	458·1 (2)	422	377·1	347·7	380	360	—	—
Vert. Diam. of Head	54·6 (5)	47·6	46·9	40·9	43	43	44·3	40·7
Hor. Diam. of Head	52·2 (5)	45·6	46·5	40·6	44	42	44·2	40·6
Min. Vert. Diam. of Neck ...	35·5 (2)	30·8	34·0	29·5	29·5	28·1	—	—
Capito-collar Length	85·8 (2)	75·6	77·1	67·9	79·0	69·3	71·7	66·0
Length of Neck	57·2 (2)	50·5	53·7	47·4	57·5	47·8	49·7	45·7
Proximal Breadth	110 (2)	100	[91·0]	[83·1]	96·1	87·4	[92·8?]	[85·3?]
Platymeric A. P. Diam. ...	28·7 (8)	25·3	26·7	23·6	27	22	24·6	21·2
Platymeric Trans. Diam. ...	39·5 (8)	35·7	31·6	28·6	33	29	31·3	27·7
Pilastric A. P. Diam.	38·6 (2)	33·9	29·1	25·6	—	—	30·9	25·1
Pilastric Trans. Diam.	30·0 (4)	27·1	28·0	25·3	27·0	20·8	26·7	22·8
Popliteal Width	45·6 (8)	41·2	39·7	35·9	39	45	35·7	33·2
Popliteal Direct A. P. Diam. ...	36·7 (8)	31·9	28·0	24·3	33	28	30·3	24·6
Diaphysial Chord	265·9 (2)	239·3	252·7	227·4	—	—	—	—
Diaphysial Subtense	11·3 (2)	10·0	6·49	5·73	—	—	—	—
Prox. Seg. Diaphysial Chord ...	114·4 (2)	112·0	95·7	93·7	—	—	—	—
Bicondylar Width	92·7 (6)	81·3	79·8	70·0	81	74	80·3	72·0
Midtrochlear Angle	6°·7 (2)	6°·5	7°·9	7°·7	11°·0	8°·0	—	—
Angle at Centre of Head ...	47°·3 (2)	48°·5	41°·6	42°·7	50°·5	42°·5	—	—
Collar Angle	126°·0 (2)	125°·0	130°·9	129°·9	118°·5	129°·5	127°·1	[126°·1]
Torsion of Femur	35°·0*	35°·0	13°·2	16°·1	—	—	17°·1	17°·1
Obliquity of Shaft	12°·5 (2) {9°·5 †}	12°·9 {9°·9}	10°·2	10°·6	6°	10°	—	—
Pseudo-obliquity	6°·0	8°·5	5°·8	7°·4	5°·5	5°·5	—	—

Oblique Direct Lengths Index ...	99·2 (2)	99·1	99·4	99·3	99·5	99·5	—	—
Oblique Troch. Lengths Index ...	98·6 (2)	98·5	99·5	99·4	99·4	99·6	—	—
Proximal Breadth Ratio ...	21·6 (2)	21·6	[21·4]	[21·4]	22·6	22·3	—	—
Distal Breadth Ratio	19·0 (2)	18·3	18·8	18·1	19·0	18·9	17·4	[17·0]
Robusticity of Femur	13·0 (2)	12·8	12·8	12·6	[14·4??]	[13·1??]	11·8	11·6
Robusticity of Head	21·5 (3)	20·7	21·0	20·2	20·3	21·3	19·7	19·7
Ellipticity of Head	99·3 (5)	99·5	98·9	99·1	102·3	97·7	99·8	99·8
Head Bust Ratio	62·3 (2)	61·7	61·3	60·7	54·4	62·0	61·6	61·6
Primary Bust Ratio	16·2 (2)	15·7	17·2	16·7	18·1	16·5	[15·9]	[15·9]
Secondary Bust Ratio	16·4 (2)	15·8	17·4	16·8	18·2	16·5	16·0	16·0
Bust Shaft Index	18·7 (2)	17·8	20·5	19·6	16·5	19·2	—	—
Capital Ratio	10·2 (2)	9·9	10·5	10·0	9·9	10·2	9·9	9·8
Capito-bicondylar Index ...	57·6 (2)	56·8	59·0	58·2	53·1	58·1	57·1	55·7
Epiphysial Ratio	92·3 (2)	91·6	96·9	96·2	97·5	93·6	90·7	90·7
Lemotic Index	11·1 (2)	10·7	12·6	11·7	13·2	11·4	11·1	11·1
Platymeric Index	73·0 (8)	70·9	85·2	82·9	81·8	75·9	83·5	83·5
Pilastric Index	125·1 (2)	123·4	104·4	101·6	—	—	109·9	109·9
Popliteal Index	81·0 (8)	77·7	70·8	67·9	84·6	62·2	81·8	81·8
Soffit Index	51·5 (4)	50·7	50·0	50·8	48·1	60·8	45·7	45·7
Index of Gracility (Upper) ...	79·3 (4)	79·0	88·8	88·6	81·8	71·7	84·8	84·8
Index of Gracility (Lower) ...	72·0 (4)	71·8	71·0	70·8	69·2	46·2	72·8	72·8
Index of Trans. Slenderness ...	6·4 (2)	6·3	7·43	7·28	7·1	5·8	—	—
Index of Sagittal Slenderness ...	[8·4 (2)]	8·0	7·71	7·36	—	—	—	—
Index of Proximal Taper ...	76·8 (2)	74·6	91·9	92·1	—	—	79·6	84·5
Index of Distal Taper	87·3? (2)	90·7	96·0	96·0	—	—	98·1	98·0
Primary Index of Bowing ...	4·26 (2)	4·18	2·55	2·50	—	—	—	—
Secondary Index of Bowing ...	43·1 (2)	46·8	36·9	41·1	—	—	—	—
Bicondylar Ratio	18·4 (3)	18·0	17·8	17·3	18·6	17·6	16·9	16·7
Distal Articulation	84·0 (1)	75·0	[74·9]	[66·0]	74	67	[75·7]	[67·1]
Distal Articulation Ratio ...	16·0 (1)	15·5	[16·7]	[16·1]	17·0	15·9	—	—
Distal Articulation Index ...	93·3 (1)	93·7	[93·9]	[94·3]	91·4	90·5	[94·2]	[93·1]

* Value given by Rodriguez. He states (Bibl. 101, p. 11) that he had 13 Cromagnon femora, but he does not give the numbers available for each individual character. The value for the Modern Negro is also based on his data. In modern civilised races the torsion appears to be higher in the female than in the male, but we cannot be sure that this is so in primitive races or prehistoric or fossil man. Manouvrier (Bibl. 71 *bis*) gives for Neolithic Man, ♂ 29°·0 (23), ♀ 27°·3 (10). In the same paper he also gives for Negroes the torsional angle 20°·7 (13). We have thought it best to repeat the male value for the female in the case of the Cromagnon woman and the negress.

† Value given by Verneau; our value is from his illustrations.

exaggerated platymery of the Cromagnon Type, and he has become relatively more concave in the popliteal area[1]. The remaining indices of the shaft show the same effect of these main shaft changes. The Soffit Index has not changed much for both Popliteal Width and Bicondylar Width have lagged in the general reduction of size; this applies also to the Distal Articulation Index. The Index of Gracility (Upper) has much increased because of the lag in the Pilastric Transverse and the accelerated decrease in the Platymeric Transverse. There is not much change in the gracility of the lower part of the shaft because Pilastric Transverse and Popliteal Transverse have both lagged. The Index of Proximal Taper has much increased because the Platymeric Antero-posterior has lagged and the Pilastric Antero-posterior has been accelerated in decrease. The Index of Distal Taper has also increased although not to the same extent as both Pilastric and Popliteal Antero-posterior Diameters have lagged but not to the same extent. To sum up Recent Man has acquired more rotiform Platymeric and Pilastric Sections and a less rotiform Popliteal Section than Cromagnon Man. In Pilastric Section he has reverted somewhat to the Neanderthal Type and in Platymeric and Popliteal Sections to the Greater Anthropoids.

If we turn to the main femoral angles, we note that the exaggerated torsional angle (35°) has been at least halved presenting thus a partial return to the lower torsion of the Anthropoids and Neanderthalloids. The Collar Angle—which is low in Neanderthal Man, increases in Cromagnon Man and reaches a value in Recent Man as high as, if not higher than, in the Anthropoids—again appears as a return since Neanderthalloid times to a more pithecoid character[2]. Bowing also which is so exaggerated in the Cromagnon and some of the Neanderthal femora has reverted in Recent Man to something like the value of the Greater Anthropoids.

As compared with Neanderthal Man, Cromagnon Man shows in his femur many of the characteristics of Recent Man. He made a really enormous stride in the development of the pilaster, the marked torsion, the bowing, the concave popliteal area, the rotiform character of the platymeric section and the great increase of length and therefore of stature. It is exactly as if he had provided the essentially human characteristics of the femur in an exaggerated form and evolution had then to retrace partially, but far from wholly, its steps. If we assume Anthropoids or Neanderthal Man—still more if we assume the Lemuroids—in the direct line of human descent we should at least have to introduce a link like Cromagnon—it may be in a less exaggerated form—before we could account for the femoral characters of Recent Man. It is for further study to determine whether the link was a modified Cromagnon, from which was side tracked our known Cromagnon, or as a more violent mutation was

[1] The Anthropoids, Neanderthal Man and Galley Hill Man are convex in the popliteal area, Cromagnon Man is slightly concave or flat, Recent Man has on the average slight convexity. These points are well illustrated in the diagrams of the popliteal sections, which certainly seem to suggest a continuous evolution in this character: see our pp. 486–487.

[2] If our value for the obliquity of the Cromagnon Type be correct or at least more comparable with the values we ourselves have found for other races, there is the same increase of obliquity in the Cromagnon Type compared with the Neanderthal Type and the same partial regression to an earlier value in Recent Man.

Cromagnon itself followed by a regression in some of the over exaggerated human features of that type.

(*c*) *Verneau's Grimaldi Type.* We now ask ourselves where Verneau's fossil negroid Grimaldi Type stands with regard to Cromagnon and Recent Man. Unfortunately we here suffer from possessing only a senile and an adolescent specimen, and for these having no torsion, no bowing and no Pilastric Antero-posterior Diameter. According to Humphry[1] the Collar Angle does not decrease with old age, and this view is also held by Charpy[2]. If this be correct the low Collar Angle of the Negroid Old Woman is noteworthy. We believe, however, that it is either senile or pathological. The appearance of the femur in the plates suggests something anomalous in the neck. Its low value, however, hinders, even if it were truly characteristic, any criterion of relationship to the other races in the table being based on it. In young children the Collar Angle is higher than in the adult, but an "Adolescent" is hardly a child, and we should not be justified in reducing the Collar Angle of the "Adolescent" by more than a degree or two at most if even this were legitimate. On the other hand we might anticipate that the distal epiphysis of the Adolescent would not be proportionately developed and accordingly not much trust must be placed in indices involving the Bicondylar Width or Distal Articulation for the Adolescent.

Now let us look at the *differentia* between the Modern Negro and Recent White Man as represented by our 17th century Londoners. The Negro has a somewhat longer femur, but no stress can be laid on this, for the femur of the Rothwell English would have been larger than these Negro femora. It is important, however, that the White Man with a small femur has a larger head (in the case of the male) and a longer neck, so that the bust is greater. There is little to choose between the two in Proximal or Distal Breadths, the Negro femur being slightly larger; the same remark applies to Distal Articulation. In the Platymeric dimensions the White is slightly the larger. The Pilastric Transverse and the Popliteal Width are somewhat greater in the White. The Collar Angle in the Negro is less than in the English, but it has a value frequently given for the French; the Torsion is probably somewhat higher in the Negro. But taken all round we may safely say that there are no *absolute* measurements, nor indeed any combination of absolute measurements, that would enable us to assert with a high degree of probability that a femur was negroid. The matter is somewhat different when we come to the *relative* proportions or indices. The Platymeric Index offers little criterion, but the Pilastric and Popliteal Indices of the Negro are markedly higher; the Soffit Index, the Index of Gracility (Upper) and the Index of Proximal Taper are markedly less. There is little difference to be noted in the Index of Gracility (Lower) or the Distal Articulation Index. The following indices are greater in the White than in the Negro although to a less marked degree than those just mentioned: the Distal Breadth Ratio and the Bicondylar Ratio—the White has relatively somewhat larger epiphyses; the Capital Ratio, the Capito-bicondylar Ratio, the Bust Ratios—the Bust is relatively greater in the White; the Lemotic Index—the neck is relatively greater in the White; the Robusticity of Femur

[1] Bibl. 45. [2] Bibl. 36.

and of Head. Lastly we draw attention to the Epiphysial Ratio which is markedly greater in the White. The following are therefore the six primary criteria: the Pilastric, Popliteal, Soffit Indices, the Indices of Gracility (Upper) and of Proximal Taper, and the Epiphysial Ratio. There are eight secondary criteria, namely: the Distal Breadth, the Bicondylar, the Capital, the Capito-bicondylar and the Bust Ratios, the Robusticities and the Lemotic Index. To these fourteen indices we must turn, giving greater weight to the first six, if we wish to test the negroid character of a femur. Now the "Adolescent" femur has the Index of Gracility (Lower) of a child between 12 and 15 years of age (see our p. 305), and therefore had at least five or six years of growth before it. Now in these years we find 42 mm. growth in the Diaphysial Length of the English ♂ femur, that is to say about 12 per cent. increase[1]. But a few rough observations show that the epiphysial part of the length of the femur is about one-seventh at the age of 14 or 15 years, and that the growth of the epiphyses is about double that of the shaft, let us say in round numbers about 25 per cent. Thus six-sevenths of the "Adolescent's" femur grow at 12 per cent. and one-seventh grows at 25 per cent., or we have a growth factor of say 1·14. The adult maximum ♂ length would be 480. To confirm this value we may take the "Old Woman's" femur, and allowing 4 mm. for senile shrinkage[2], we have a maximum length of 440 for the female, giving a sex ratio of 1·091. The sex ratio of our 17th century Londoners' femora is 1·093; the sex ratio in *stature* of British Round Barrow is 1·090, of Ancient Anglo-Saxons 1·096, of Swiss Alemanns 1·091—thus the value found is not excessive especially in the case of tall primitive races. We have thus two distinct processes open to us to ascertain the adult male Grimaldi Type, *i.e.* (i) to allow say 1 per cent. senile shrinkage to the "Old Woman" and use the sex ratio of the 17th century Londoners, or (ii) to use the above growth rates. Let us test the two methods on fundamental characters. (*a*) *Vertical Diameter of Head*: Sex Ratio gives 50, and Growth Rate 54, we take it at 52. (*b*) *Proximal Breadth*: Sex Ratio gives 106 and Growth Rate 109, we may take it at 107. (*c*) *Bicondylar Width*: Sex Ratio gives 93·5, Growth Rate 92·5, we may take it at 93. (*d*) *Minimum Vertical Diameter of Neck*: Growth Rate 35, Sex Ratio 34. (*e*) *Oblique Length*: Sex Ratio 480, Growth Rate 478, say 478. (*f*) *Capito-trochlear Length*: Sex Ratio 466, Growth Rate 467. (*g*) *Shaft Length*: Sex Ratio 413, Growth Rate 410, say 411. These results are in quite good accordance. The trochanteric lengths are far less satisfactory because we have so little information about the growth of the great trochanter; between 14 and adult age its growth must be very large, far exceeding the growth of the epiphyses. We can only in our ignorance base these values on an average trochanteric sex ratio of 1·096. The sex ratios for the antero-posterior and transverse dimensions of the shaft are more varied; the transverse for the platymeric, pilastric and popliteal sections is very close in all cases tested to 1·106; the antero-posterior is about 1·134 for platymeric and pilastric sections, but as high as 1·152 for

[1] *Modern* English adult femur has for the male a diaphysial length of about 390, and for 14 years 348.

[2] The state of the neck suggests that 1 per cent. shrinkage is rather under than over the mark.

the popliteal. We will take 1·143 to represent the sex ratio for antero-posterior measurements of the shaft.

When we turn to the growth changes in the shaft between 14 years and the adult, the changes are very complicated. It is not only that the size but the shape of the shaft sections alter. The platymeric section loses much of its platymery, *i.e.* the antero-posterior grows at a greater rate than the transverse diameter; the rates of growth being approximately 1·4 and 1·2 respectively. The popliteal section loses its elliptical and tends to a more circular form. We believe the popliteal width to remain nearly constant while the popliteal antero-posterior diameter grows with a rate of growth of about 1·2. That is to say an adolescent is more apelike in popliteal section and more Neanderthalloid in platymeric section, or more "orangoid" in both than an adult. Our numbers are only the roughest, based, indeed, on the slenderest of data, but we think they express the main lines of change, and on the basis of them we have made our appreciations of the absolute shaft dimensions of the Grimaldi Type male. With the indices greater freedom of judgment must be allowed, for our sex rates and still more our growth rates are only round figures and small changes in value very sensibly affect these indices. We have therefore found the indices from the reconstructed absolute values for the adult male, and then compared these indices with those of the "Old Woman" and of the "Adolescent," giving weight in the latter to the possible growth changes and in the former to what we have learnt of sex differences in the femoral indices in the course of this work. Thus a variety of considerations have been called into play, and we can only say we have done our best possible to create not the "Adolescent" as an individual adult, but the adult male Grimaldi Type as far as can be deduced from the very slender material at our disposal. These values are given in Table III of this chapter and should be compared with the indicial values of the "Old Woman" and the "Adolescent" as given in the second table.

If we ask what are the main features of the Grimaldi Negroid Type thus reconstructed, we must answer (i) a very considerable reduction in size of shaft from the Cromagnon Type but the shaft still remains much above the average of Recent Man, and (ii) only a small reduction in the massive character of the epiphyses which are but slightly less than those of the Cromagnon Type.

In the following table we extract some of the data for the fundamental dimensions in order that the trees may not hinder the reader from seeing the wood.

These figures are of course only roundly approximate, but they do suffice to prove that the problem of whether Verneau's Grimaldi race is nearer to the white or to the negro is non-existent as far as the size of the femur is concerned. The race must have been very much bigger than the average type of Recent Man, whether white or black[1]. *In absolute size it lies between Cromagnon and Recent Man, and is much*

[1] Bavarians or Rothwell English would have given a result for whites rather in excess of the available sample of negroes. A tall race of negroes might again invert the order as to size. What is obvious is that our 17th century Londoners and the Modern Negroes represent Recent Man, and the Grimaldi Negroid Type differs widely from them with close links to Cromagnon.

SUBTABLE V. *Comparison in Fundamental Lengths, etc. of Cromagnon, Grimaldi and Recent Man.*

Character	Cromagnon ♂	Negroid Grimaldi		Recent White		Modern Negro	
		♂	♀	♂	♀	♂	♀
Maximum Length ...	528	480	440	447	409	452	416
Trochanteric Length ...	511	467	430	426	389	—	—
Shaft Length	458	411	383	377	348	—	—
Proximal Breadth ...	110	107	97	91	83	93	85
Vert. Diam. of Head ...	55	52	43	47	41	44	41
Length of Neck	57	60	58	54	47	50	46
Bicondylar Width ...	93	93	82	80	70	80	72
Distal Articulation ...	84	84	75	75	66	76	67
Collar Angle	126°	128°	?	131°	130°	127°	126°
Torsion	35°	—	—	13°	16°	17°	17°
Bowing	4·3	—	—	2·6	2·5	—	—

nearer to the former in massiveness of epiphyses. It may be looked upon as a link between the two in which some of the exaggerated size of the Cromagnon shaft has been already lost, but the exaggerated massiveness of the epiphyses not yet substantially reduced.

We can now turn from absolute size to the indices and ask if this more precarious material provides any clear evidence of the negroid character of Verneau's Grimaldi femora.

Primary Criteria.

(i) *Pilastric Index.* We have not the pilastric antero-posterior diameter and our direct inquiry has failed to procure it.

(ii) *Popliteal Index.* Old Woman 84·6, Adolescent 62·2, Reconstructed Adult Male 80·0. Probably close to Cromagnon value. Apparently near to Modern Negro also, but we believe the high value of the Modern Negro is due to Hepburn's determination of the popliteal diameters differing from ours: see our p. 124. Under the circumstances this criterion is of no value; all we can say is that the Grimaldi Type is like the Cromagnon, which in this respect *may* be nearer Modern Negro than Recent White, but Hepburn gives 78 for Modern British, a value 7 points in excess of our 17th century Londoners. Thus by our method his Negroes might be 75—a value as remote from the Grimaldi as from the Cromagnon.

(iii) *Soffit Index.* Old Woman 48·1, Reconstructed Adult Male 48·4. These values are intermediate between Cromagnon and Recent White and are not at all modern negroid.

(iv) *Index of Gracility (Upper).* Old Woman 81·8, Reconstructed Adult Male 82·3. Intermediate between Cromagnon and Recent White, but near the former. They are nearer to the Modern Negro than Recent White, because the Modern Negro is about half way from Cromagnon to Recent White.

(v) *Index of Proximal Taper.* Unascertainable.

(vi) *Epiphysial Ratio.* Old Woman 97·5, Reconstructed Adult Male 94·5. Values very divergent from the Negro and in their mean intermediate between Cromagnon and Modern White, but nearer the latter.

Thus of our six primary criteria two fail to be of service; in one case the Grimaldi femora are nearer to the Modern Negro than to the Recent White, but in this case they are close to the Cromagnon value, which diverges considerably from that of Modern Negro. In the remaining cases the criteria are markedly in favour of the Grimaldi Type being an intermediate between Cromagnon and Recent White, and in these cases the Modern Negro lies *outside* the Cromagnon to Recent White range.

Secondary Criteria.

(i) *Distal Breadth Ratio.* ♂ 19·9, ♀ 19·0. Grimaldi Type close to Cromagnon and far nearer to Recent White than to Modern Negro.

(ii) *Bicondylar Ratio.* ♂ 19·0, ♀ 18·6. Fairly close to Cromagnon and remote from Modern Negro.

(iii) *Capital Ratio.* ♂ 10·2, ♀ 9·9. Identical with Cromagnon and nearer to Recent White than to Modern Negro.

(iv) *Capito-Bicondylar Ratio.* ♂ 56·0, ♀ 53·1. Nearer to Modern Negro than to Recent White but not far from Cromagnon.

(v) *Bust Ratio.* ♂ 17·7, ♀ 18·2. High values but both nearer to Recent White than to Modern Negro. The divergence from Cromagnon is due to the retention of the long bust with the reduced shaft.

(vi) *Robusticity of Femur.* Unascertainable as a result of our ignorance of the pilastric antero-posterior diameter.

(vii) *Robusticity of Head.* ♂ 23·4, ♀ 20·3. The mean is practically identical with that of Cromagnon and not far removed from Recent White; divergent from that of Modern Negro.

(viii) *Lemotic Index.* ♂ 12·6, ♀ 13·2. Male as that of Recent White, female in excess of Recent White. Values much nearer those of Recent White than of Modern Negro or Cromagnon.

Summing up our views as based on the above evidence we should say that we have not succeeded in finding any specific modern negroid features in the Grimaldi fossil femora. These femora appear to us to have characters which place them in indices as in absolute size on the whole intermediately between the Cromagnon Type and Recent Man, and their features are in a number of cases closer to the former than the latter. The crania may give more marked negroid characteristics, and we may be dealing with a branch point, where the negro left the ancestral line, but on the basis of the femur alone we consider that Verneau's Grimaldi Negroid Type suggests strongly an intermediate link to Recent Man. It retains several of the Cromagnon features which Recent Man has retained, and it has begun the reversionary process which wiped out some of the exaggerated features of the Cromagnon Type. We look forward with the greatest interest to the possible discovery of an adult male of the Grimaldi Type. That type will have enhanced value, if we regard it not as a migratory variant, but as a stage in the Cromagnon to Recent Man direct line. Our view is, of course, not a

dogma but a suggestion, but it is a suggestion which appears to us supported by the osteometric data we have just discussed[1].

(*d*) *Position of Neolithic Man.* If the Grimaldi Type may be taken as an intermediate between the Cromagnon Type and Recent Man[1], although in several features closer to the former, have we any clue to another intermediate which is closer to Recent Man? We think it is distinctly suggested in the characters we know of Neolithic European Man. In Neolithic Man the size of the femur is already that of Recent Man in both diaphysis and epiphyses, but there is still exaggerated torsion, pilaster and platymery. We may take as a compact group Manouvrier's measurements on 23 ♂ Neolithics from Châlons-sur-Marne[2].

SUBTABLE VI. *Comparison of Cromagnon, Neolithic, and Recent Man.*

Character	Cromagnon Man	Neolithic Man	Recent Man
Maximum Length	528	444 (—)	447
Oblique Length	519	441 (444)	445
Vertical Diameter of Head	54·6	46·5 (46·0)	46·9
Platymeric Index	73·0	76·1 (75·1)	85·2
Pilastric Index	125	108 (111)	104
Collar Angle	126°	128° (128°)	131°
Obliquity	12°·5	10°·2 (—)	10°·2
Torsion	35°	29° (19°)	13°

The numbers in brackets under Neolithic Man are those given by Rodriguez for larger but far less homogeneous material. It appears to us that with Neolithic Man the fitting size of the femur had been in broad lines determined, but the sections of the shaft and the torsion remained to be still further modified.

(*e*) *Femur of the "Fringe" Races.* If, as we suggest, the Grimaldi Type and Neolithic Man are not branch lines, but direct links in the chain from Cromagnon Man to Recent Man, and if the series in time order be really a series in evolutionary order, we have still to consider whence the Cromagnon Type itself has sprung. With that type appeared, as we have noted, several of the most characteristic features of the femur of Recent Man, albeit in an exaggerated form. A careful study of the data provided in Table III[3] will suffice to show the reader that the exaggerated Cromagnon features

[1] Perhaps some further evidence may be deduced from the shape of the patellar surface. In the Cromagnon Type there is not the asymmetrical laterally peaked form typical of Recent Man. It is more like the Neanderthal type of patellar surface, which is distinctly more apelike than that of Recent Man. In the Grimaldi Type, to judge merely from the uncertain photographs, the patellar surface is markedly peaked on the lateral side—there is a distinct departure from Cromagnon towards Recent Man.

[2] Bibl. 71 *bis*, p. 162.

[3] The reader must be careful to neither over- nor under-estimate the value of Table III. We know only too well the shortness of our ape series; we have already endeavoured to impress the reader with the difficulties that have arisen in the case of the femora of Primogenial Man—the diversity and paucity of measurements that have been published and the impossibility of ourselves verifying them in the present state of affairs. We must again emphasise the struggle we have had to obtain anything like consistent results in patching together the meagre data that exist for our representative races of man. It would be idle to give a long string of cases—one will suffice, for it is typical of a whole series of instances. Flower deals with the osteology of the Andamans and gives one measurement only of the femur, presumably its

have been preserved to a more marked extent in Neolithic than in Recent Man, but have been retained in a remarkable manner in certain of the fringe races. Thus the Guanches had much of the platymery (76·1), a good deal of the pilastry (111), the low collar angle (124°) and several other features of the Cromagnon Type. Extremely low platymery (68·6 and 63·1) combined with pilastry of the neolithic order is found in Fuegians and Moriori (Scott: Maori ♂ 123·4, Moriori ♂ 117·4) femora. The Polynesian is in these features more closely related than the Australian to the Maori. Indeed the Australian femur is in many respects remarkable; its platymery is that of a modern European, its pilastry and size are suggestive of Cromagnon; but its low Soffit Index and its low Collar Angle (44·9 and 119°) carry us back to Neanderthalloid Man (45·8 and 115°), from which however it differs widely by its reduced robusticities. It is a relatively slender femur with a small head, and except in a few isolated characters it seems to us an error to directly associate it with that of Neanderthal Man. The most we can say of Recent Man is: that isolated features of Primogenial Man whether of the Neanderthal or the Cromagnon Type are still to be found in the fringe races—that the transition from Cromagnon to Recent Man is far easier than the transition from Neanderthal Man to Recent Man would be without a Cromagnon-like link as we should have then to invent such a link to supply the characteristic Cromagnon features.

At the same time if the reader will carefully study the *proportioning* of the femur of Recent Man as given in our columns of mean values of indices in selected groups of Recent Man, he will note (i) that the indices of the shaft are surprisingly close to those of Neanderthal Man, on the whole far closer than to those of Cromagnon Man, (ii) that on the other hand the indices of the epiphyses are, where comparison is

maximum length in the case of the 29 skeletons he had available: ♂ 393·4, ♀ 380·4. These values are clearly incompatible with the oblique lengths as obtained from other writers. To introduce them would be to make an impossible Andamanese femur. We have had to discard them entirely—not because they are essentially erroneous, but because Flower went no further than merely measuring *one* character, and gave us no means therefore of bringing his results into line with those of other investigators. Numerous other rejections have had to be made in like manner. Where we have endeavoured to build up a racial femur from contributions from different sources we have exercised the best discretion we could. But it must be distinctly understood that our table is rather a scheme for future filling in than an accurate representation of the femoral characters in the five main divisions of Recent Man. Only in the columns of our 17th century Londoners is the material homogeneous in source and methods of measurement. Elsewhere we have combined material, used reducing factors, and selected what data it was possible to include. Doubtful measurements or measurements obtained by doubtful reconstructions are enclosed in square brackets. The reader will find that in some cases indices are the ratio of the mean characters provided; in others the indices were given by one writer and the absolute values are deduced from a different series of femora by other writers. We have selected, where available in adequate numbers, the indices as found by one writer from his own material. But this is not always possible; a French writer may give the Capito-collar Length, but take no measurements on the Distal Epiphysis; an English or German writer may give the Bicondylar Width; thus for even a rough appreciation all we can do is to combine mean values obtained on different series for the Epiphysial Ratio. All we claim for our table is that it represents in a rough approximate way the femur of Recent Man in its chief groups—paying special attention to the "fringe" races. Further our last two columns, while not wholly self-consistent, not really characteristic of any one race or one individual, give the characteristic features of the femur of recent *Hominidae* as distinguished from the like features in general of *Simiadae* or *Lemuroidea*. It may be said that this is a small matter, but it appears to us capable of throwing some light on the path of man's ascent.

possible, apparently closer to those of Cromagnon Man than to those of Neanderthal Man. Thus just as if Cromagnon be not an ascendant we should have to insert something like Cromagnon to give the characteristic femoral features of Recent Man, so without Neanderthal we should need to insert something like Neanderthal Man to provide those divergences in the shaft indices from Cromagnon which we have referred to in Recent Man[1]. We can either insert such branch-points in our evolutionary ancestry,—links which will then still remain to be discovered,—or we can take a great forward leap of the femur in Cromagnon Man with a regression since in the direction of an earlier Neanderthal Type; and with this regression in a certain limited sense the human femur has become more apelike. The Cromagnon femur has few apelike characters, but its exaggerated human features were in some manner incompatible with success and the femur of Recent Man stands in several respects between the Cromagnon and Neanderthal Types. The Cromagnon branch-point—if it be a branch-point at all—stands nearer to Recent Man than the Neanderthal branch-point, for it provided features that are strictly recent human and which we scarcely find at all anterior to it.

(*f*) *Position of Galley Hill Femur.* Suppose either case—and one or other seems to us a necessity—Cromagnon and Neanderthal ancestors, or Cromagnon and Neanderthal branch-points with femora like these types in possibly less exaggerated forms, then the main difficulty seems to us to lie not in the accepting of such a line of descent, but in finding links between these two types or at least between the branch-points corresponding to them in the direct human line of ancestry. Thus far—and there are difficulties to be cleared up—we have only come across the Galley Hill femur as anything like an intermediate, but it does provide certain good sequences in the more important characters—if others, possibly owing to the difficulty of reconstruction, raise considerable doubts. In the first place the Galley Hill femur shows at least the beginnings of a pilaster, which practically fails in the Neanderthal Type; its popliteal section is by no means a bad intermediate between those of *Homo mousteriensis* (*Hauseri*) and of the Cromagnon R. (see Diagrams, p. 486) and it has a large assortment of the "anomalies" of Recent Man, which are almost specific characters of the Neanderthal Type (see our p. 456 ftn.). In the second place the Galley Hill femur as it stands is in many measurements already an intermediate; it is an intermediate in a good many more —if, as we suspect, it is a *female.* Thus we should have approximately the system on the following page, taking the Fuegians sex-ratios, as the most fitting for the case.

Now this table indicates the great divergence of the Galley Hill femur from that of Recent Man. The basis of resemblance is just in those characters where Recent Man has reverted from the Cromagnon towards the Neanderthal Type. The examination of the indices of the shaft is less satisfactory—in large measure we believe owing to the bad condition of the Galley Hill bone. But even here an examination of Table III will show that these indices do not strengthen the relation of Galley Hill

[1] The marked bowing, the pilaster and the torsion, the Cromagnon features of Recent Man, also concern the shaft. Notwithstanding it is not incorrect to assert that the *proportioning* of the shaft in Recent Man is more Neanderthalloid than Cromagnon-like in character.

SUBTABLE VII. *Comparison of Neanderthal, Galley Hill, Cromagnon and Recent Man for male Femora.*

Character	Neanderthal	Galley Hill	Cromagnon	Recent Man
Maximum Length	423	456 (424)	528	441
Oblique Length	420	455 (423)	523	436
Vert. Diam. of Head	52·3	52·9 (49·2)	54·6	45·1
Vert. Diam. of Neck	37·0	40·7 (35·3)	35·5	33·6
Capito-collar Length	75·0	77·6 (72·2)	85·8	72·5
Length of Neck	46·4	51·2 (47·6)	57·2	50·0
Proximal Breadth	102	108? (100·1?)	110	88·8
Popliteal Width	40·3	48·2 (44·8)	45·6	36·0
Bicondylar Width	87·6	94·6? (88·0?)	92·7	78·7
Torsional Angle	10°·2	15°·0	35°·0	19°·5
Collar Angle	115°·0	126°·0	126°·0	127°·4
Obliquity	4°·1	8°·5	12°·5	9°·8
Proximal Breadth Ratio ...	25·1	(24·6?)	21·6	21·3
Distal Breadth Ratio	21·6	(21·6??)	19·0	18·7
Robusticity of Femur... ...	14·3	12·6* (12·4)	13·0	12·4
Robusticity of Head	25·0	23·3	21·5	20·6
Head Bust Ratio	72·7	68·3	62·3	62·3
Primary Bust Ratio	17·2	17·0	16·2	16·6
Bust Shaft Index	20·2	19·9	18·7	20·5
Capital Ratio	12·4	11·6	10·2	10·5
Epiphysial Ratio	83·0	(82·0?)	92·3	94·5
Bicondylar Ratio	20·8	20·7?	18·4	17·9

* For reasons previously given we think the Pilastric Tranverse is under-estimated.

to Recent Man ; if they could be trusted, which we doubt, they would suggest that in some respects Galley Hill was more pithecoid than the Neanderthal Type. The conclusion that suggests itself to our minds is that Galley Hill is a most valuable link, either directly between the Neanderthal and Cromagnon forbears of man or at least between the Neanderthalloid and Cromagnon branch-points in the human pedigree. In this respect it appears to us as one of the most valuable of the "finds."

The time may come when we are able to give our judgment as based on the crania, but on consideration of the femora only we suggest that the Galley Hill Type is a Neanderthal-Cromagnon intermediate and the Grimaldi Negroid Type a Cromagnon-Recent Man intermediate.

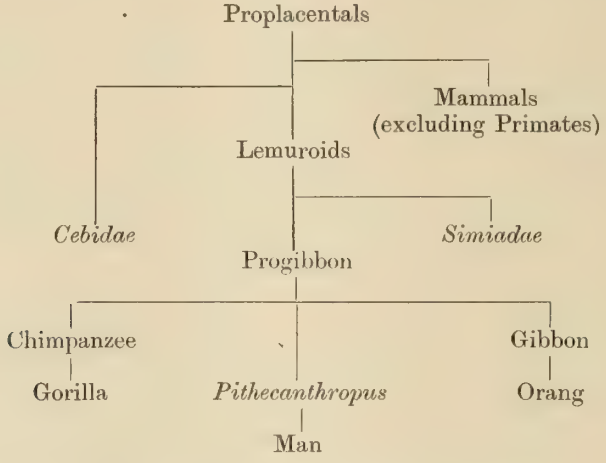
(iv) *On the supposed Hylobatic Ancestry of Man.*

(*a*) *Arguments based on the Anomalies.* If this view be approximately correct—*i.e.* that before reaching the femur of the ape-man the human femur must have passed through a massive bowed and pilasterless form, through something approaching the Neanderthalloid femur, if not that femur itself—it seems erroneous (i) to give the femur of the true *Pithecanthropus* the Recent Man form of the Trinil femur, and then (ii) to link this form up with the immediate ancestor of the gibbons with its slender, non-robust, non-bowed, and almost pilasterless femur[1]. The Neanderthal femur

[1] Haeckel in his *Natürliche Schöpfungsgeschichte*, Zweite Ausgabe, 1870, S. 571, links Man more closely to the Gibbon than to the Chimpanzee.

suggests that the femur of *Pithecanthropus erectus* when found will have far more kinship with those of the greater anthropoids than with either the Trinil femur or that of the gibbon—although it will undoubtedly be closer to the fossil *Dryopithecus* than to recent *Hylobates.* The common ancestor of the gorilla, the chimpanzee and the orang would possess the needful robusticity, the bowing and the insignificance of the pilaster. We may ask : which of the three greater anthropoids comes nearest to man[1] as far as the femur is concerned ? As a step towards throwing light on this problem we shall discuss the anomalies of the femur.

It is well, however, to remind the reader first of the form of pedigree which has been propounded for the primates. Haeckel[2], if we start with the Proplacentals, has the following scheme :



According to this scheme the New World Monkeys diverged, not from the Lemuroids, but from some ancestor of the Lemuroids nearer to the branch-point of the "Mammals" (Primates excepted!) ; if this view be correct lemuroid characters would be more likely to occur in the *Simiadae* than in the *Cebidae.* Again a Progibbon is made ancestor of the three lines, (i) Gibbon leading to the Orang, (ii) *Pithecanthropus* leading to Man, and (iii) the Chimpanzee leading to the Gorilla. We must suppose the femur of the Progibbon to be not very widely removed from that of *Dryopithecus rhenanus.*

Abel[3] holds that *Dryopithecus* may have been a forerunner of the Orang, but has

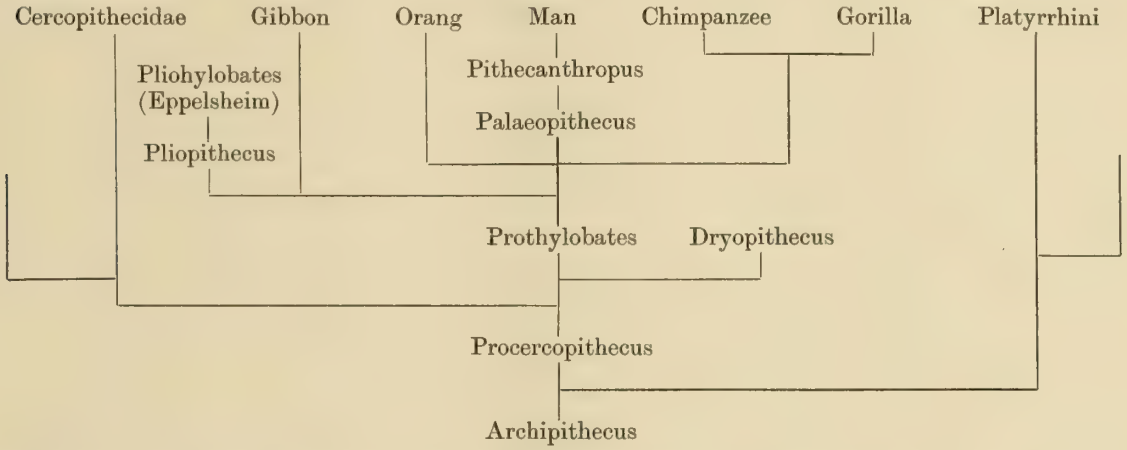
[1] Any descent of man from a type close to that of one of the existing anthropoids is, we believe, to be repudiated, and the principle involved in the statement that man is descended from an ape, only enforces the previous existence of a man-ape from whom Primogenial Man and the anthropoids are alike descended. Indeed it would be just as true—or false—to assert that the gorilla is a degenerate man as to suggest that man is an emended gorilla. The femur—and what is more, the skull—of an infant man bears little resemblance to those of the adult gorilla, but the femur—and above all the skull—of an infant gorilla are far more human in character than their adult forms. Indeed the skull of the infant gorilla is far more human in character than the skull of any *adult* ape whatever. This fact is at any rate a warning that we must not be intensely surprised if the skull of the ape-man—of the common ancestor of man and the anthropoids—were more human and less baboon-like than has been generally supposed. Without being wildly hypothetical one might dream of the real *Pithecanthropus* as a Neanderthalloid dwarf with a cranium approaching that of an infant gorilla !

[2] Ernst Haeckel, *Last Words on Evolution,* 1905, Plate I, English Translation of same year.

[3] Bibl. 87 *ter.*

no genetic relation to *Pithecanthropus erectus*—presumably he considers the Trinil femur belongs to the latter, but he is arguing from the teeth; Schlosser holds *Dryopithecus* not to be a forerunner of man, although he considers that the ancestor of man had a femur not unlike that of *Dryopithecus*. Pohlig takes the order of relationship, Orang, Gorilla, Chimpanzee, *Dryopithecus*, Man; and Gaudry, *Dryopithecus*, Gorilla, Pliopithecus, Gibbon, Orang, Chimpanzee, Man. It is not quite clear what these relational orders signify, but the origin of their differences with regard to *Dryopithecus* seems to be the relative weight which various authorities place (i) on the great divergences in the form of the mandible between Man and *Dryopithecus* and (ii) on the resemblance of the teeth, which in *Dryopithecus* are said to be the most human of all the anthropoids. No direct comparison seems to have been made of the femora.

Dubois gives the scheme[1]:



and Schwalbe[2] gives *Pithecanthropus*, Primogenial Man, Recent Man, both judging, we believe, more by the skull than the femur.

Now it will be seen that most of these orders give either a gibbon-like ancestor to man, or place *Dryopithecus* in relatively close proximity to Man. Now this would not be so hard to accept in the case of the femur, if the ancestral line were: Eppelsheimer femur, Trinil femur, Recent human femur[3]. But we have to bear in mind that both the Cromagnon and Neanderthal Types have to be accounted for, and we may safely assert that from the standpoint of the femur, it is exceedingly difficult to

[1] Bibl. No. 70 *bis*, S. 21. [2] Bibl. No. 94 *ter*.

[3] Here also is the difficulty of Schwalbe's order—the Trinil femur is wholly that of Recent Man, how can we interpose the Neanderthal Type or even Cromagnon Type between these two? It seems absolutely needful to separate the Trinil femur from the skull, if we are to accept Schwalbe's order. The same objection applies even more forcibly to Dubois' extended pedigree. He separates, contrary to the views of Abel (Bibl. No. 87 *ter*, S. 1171 *et seq.*), the Eppelsheimer femur from the mandible and other fragments of *Dryopithecus*. We must suppose *Procercopithecus* to have had the considerable bowing and robusticity of the *Cercopithecidae*, that these are lost in *Prothylobates*, are recovered in marked degree at the anthropoid branch-point, are lost again at *Palaeopithecus* or at *Pithecanthropus*, resumed in Neanderthal Man and to some extent lost again in Recent Man. Having made no independent study of the *Dryopithecus* fragments we are perfectly neutral on the question of whether the Eppelsheimer femur is that of a *Dryopithecus*. When we speak of *Dryopithecus* in relation to the femur we always refer to the Eppelsheimer bone, the femur of Abel's *Dryopithecus rhenanus*.

interpose a gibbon-like ancestor between the branch-point of the *Simiadae* and Neanderthal Man!

Take, for example, the character of bowing; this is well marked in the *Simiadae*, it is well marked in Neanderthal Man, and it is retained, if in a less emphasised manner, in Recent Man. The gibbon has *negative* bowing and *Dryopithecus* very slight positive bowing. The *Cebidae* show considerable variation in bowing, but possess a sensible positive bowing on the whole. The Lemuroids show slight or negative bowing, and Haeckel's pedigree would compel us to assert that bowing had *twice* appeared and then disappeared in the Primate descent! It is much more probable that *Cebidae* and *Simiadae* both came from a common bowed form, possibly Lemuroid in character or that the Lemuroids lie on a branch line. Again, is it reasonable to insert an unbowed gibbon-like ancestor between the branch-point of the highly bowed *Simiadae*, and the highly bowed Greater Anthropoids and Primogenial Man?

We may take it that the appearance of a rare anomaly in one primate, which is characteristic of another, is a strong indication of the order of descent, or at least of relationship. Lemuroid characters undoubtedly occur in Man, *i.e.* such features as the lateral protrusion of the anterior face, the presence of a third trochanter, and even that frontal ridge which we have ventured to call the "anterior pilaster[1]." Our Plate LXV shows a case of lateral protrusion and anterior pilaster in man, such as occur in the lemurs, and may even be found as far back as the mammals and marsupials[2]. Now, lateral protrusion of the anterior face is almost as rare in the *Simiadae* as in Man, and presumably was so in their branch-point; it is probably a relic of Lemuroid ancestry. Are we to insert a primate (*i.e.* the Gibbon) which has lateral protrusion as a characteristic between the branch-point of the *Simiadae* and those of the Greater Anthropoids and Man?

Again, a considerable number of the *Simiadae* have sensible traces of a pilaster; in some cases the apex of the popliteal surface is appreciable. There are no traces of a pilaster in the Gibbons and but little significant in *Dryopithecus*. In the Lemuroids the popliteal apex cannot be determined, and it cannot be determined in the Gibbons or *Dryopithecus*. Are we to interpolate this pilasterless, apexless form between the branch-point of the *Simiadae* and the immediate ancestor of Man? Even in the anthropoids some rough guess may be made at a popliteal apex, and the posterior face, if lacking the pilaster in the classical sense, far more nearly resembles that of Neanderthal Man than that of the Gibbon. Again, the femoral head in the case of the Gibbon has a relatively large and irregular fovea. This fovea strangely enough is absent in the Orang. It is occasionally absent or practically absent in the case of Man. This

[1] An indication of what we mean by a "frontal pilaster" is to be seen in *Dasypus sexcinctus*. Cf. Fig. III of our Plate XXVII, and it may also be traced in the common rabbit, Fig. IV of the same plate.

[2] An illustration (see our p. 342) of a "lemuroid" human femur with lateral protrusion of the anterior face and frontal pilaster is provided by Martin in a photograph of a Fuegian femur (Bibl No. 111 *bis*, S. 1023). It is not given, however, as illustrating these points. We owe to the great kindness of Professor Martin a cast of this femur. It convinces us that a study of the anomalies of the femora of the Fuegian and other "fringe" races would be of much interest.

point was unfortunately not regarded when the London femora were examined for anomalies. But in re-examining 140 of these femora for another purpose, practical absence—a small, slightly rough patch not hollowed out—was noted in one case[1]. In this respect there is accordingly another link between Man and the Greater Anthropoids which is lacking in the case of the Gibbon. The third trochanter in a marked form is more frequent in Man than in the Gibbon, and this again is an objection to the interpolation of the Gibbon between the Lemuroids and the Ape Man[2].

We turn now to the *fossa hypotrochanterica*. As far as we are aware it has not hitherto been noted as characteristic of any primate, and it has only been described as an anomaly in the case of Man. In some of the *Simiadae* there is a posterior fossa, but it runs sagittally down the posterior face, and cannot, we believe, be identified with the *fossa hypotrochanterica* in Man. At first sight this anomaly appears to be peculiar to him. Another *fossa* peculiar to a primate, but always occurring, is the *fossa angulolateralis* of the Gorilla. It is asserted that the *fossa angulolateralis* never occurs as an anomaly in Man. We ourselves have never noted in the human femur the lower portion of the spiral of this fossa on the lateral face of the femur, *i.e.* the part which is so characteristic of the gorilla femur. But traces of the *fossa angulolateralis* are to be found in both orang and chimpanzee, and it seems almost possible to insert a series of individual chimpanzee femora bridging the stages from the full *fossa angulolateralis* of the Gorilla to the *fossa hypotrochanterica* of Man. See our Plate LXII. If no vestige of the *fossa hypotrochanterica* is to be found in the Greater Anthropoids, and no vestige of the *fossa angulolateralis* in Man, then the link between the Greater Anthropoids and Man must ante-date the appearance of both these *fossae*. Yet the further we go back in the history of Man, the more marked and frequent becomes the *fossa hypotrochanterica* (see our p. 453). Again, the *fossa angulolateralis* bears the character of a vestige in the Orang, and would appear to be vanishing in the Chimpanzee, if it be not developing into something bearing close resemblance to a hypotrochanteric *fossa*. If the link between the Orang, Man and the Chimpanzee were actually a pro-Gibbon even of the approximate type of *Dryopithecus rhenanus*—having a femur without any sign of either *fossa*—we should have to imagine both *fossae* developing *de novo* in three lines traced from a living form which shows no signs of either. Is it not more reasonable to suppose that the common ancestor of Man possessed a *fossa* somewhat resembling the *hypotrochanterica* of Primogenial Man, which developed through the Chimpanzee forms into the exaggerated *fossa angulolateralis* of the Gorilla, and appears in a weakened form in the Orang, while in Man, from frequent appearance in Primogenial Man,

[1] In Cunningham's *Anatomy* (Thompson), followed in Quain's *Anatomy* (Bryce), there is a statement that human femora have been recorded without the pit or *fovea capitis*. We have been unable so far to trace the statement to its original source.

[2] Klaatsch (Bibl. 102 *bis*, S. 567) provides an octopodous pedigree of a novel if not easily interpretable kind! It would suggest that Mikronegroids and Australians are closer than any of the Greater Anthropoids to the *Propithecanthropus*. It does not help as the Gibbons are not taken into consideration to throw light on our present problems.

it has become merely an anomaly in Recent Man? If this view be not accepted we have to explain the *rise* as well as the decline of the *fossa angulolateralis* in the Orang, its continuous rise in the Chimpanzee-Gorilla line and the rise and fall of the hypotrochanteric *fossa* in the human line. Occam's razor suggests that it is better to replace the non-fossed pro-gibbon by a fossed individual[1], *i.e.* one having a femur of greater robusticity and muscularity than *Dryopithecus rhenanus*. To obtain such unity of origin a fuller inquiry as to a possible link between the *fossa hypotrochanterica* and the *fossa angulolateralis* would be well worth making.

We now turn to the vexed question of the curvature of the popliteal area, or rather of the posterior face, of the standard popliteal section taken parallel to the standard horizontal plane at one-tenth the diaphysial length from patellar articular border. The diagrams on pp. 486—7 illustrate the nature of these sections in Man and the Anthropoids. In the Gorilla we have extreme convexity, somewhat lessened but still marked in the Chimpanzee. The Gibbon has about the same degree as the Chimpanzee, and the section of the Eppelsheimer femur (*Dryopithecus rhenanus*) is very similar to that of the Recent Gibbon (*H. müller*i), except that the internal supra-condylar ridge is more emphasised. A change, however, comes over the posterior face of the section when we turn to the Orang; the curvature is zero or the section may even be very slightly concave. At first sight this may appear to be a special development of the Orang, but we must be cautious in judging this because other characters as well as this (*e.g.* the low great trochanter) are common to Man and the Orang. Turning to the popliteal section of the infant Gorilla, we see that it bears a close resemblance to that of the Orang, the posterior face is flat even to a slight concavity. The popliteal sections of the infant Orang and of the infant Chimpanzee are both very similar to that of the Gorilla, differing only in size, and the suggestion is that the common ancestor of Orang, Man and Chimpanzee had a flat rather than convex popliteal surface. The Chimpanzee-Gorilla line and Man in the Neanderthal Type line developed the convex popliteal surface. Turning to the sections of the human femur, we see that Neanderthal L., Spy R., *Homo mousteriensis* (*Hauseri*) L., Galley Hill L. form an almost continuous series with increasing flatness of the posterior face of the section till we get the transition to perfect flatness or even slight concavity of the Orang type in Tilbury L. and Cromagnon R., and the series culminates in the distinguishable, but not very marked or always present, concavity of the popliteal area of Recent Man (see our pp. 486 and 487).

Another feature which is of interest in this section is the slight concavity of the anterior face on the mesial side; it does not occur in any of the Anthropoids to our knowledge—in the Gorilla the slight flattening is, if anywhere, on the lateral side of the anterior face. But it is present in Neanderthal Man, is traceable in Galley Hill and marked in Tilbury and Cromagnon. We should expect to find it relatively

[1] It may be noted that in the infant gorilla the femur has the *fossa angulolateralis* in its lower part as a slightly depressed rugous trough, much like the vestigial *fossa* of the adult Orang; the hypotrochanteric portion of it may be more depressed and smoother floored, but is somewhat more to the frontal border of the lateral face than is usual with the *fossa hypotrochanterica* in Man.

insignificant in the Grimaldi Type. It is scarcely traceable, or appears only as an anomaly, in Recent Man[1].

The general result of this examination of the popliteal curvature would seem to be that a common ancestor for Man and the Greater Anthropoids is indicated with a more orangoid than gibbon-like popliteal surface, and that we should side-track *Dryopithecus rhenanus* and *Prothylobates*. The individual who should stand at the branch-point of Orang, Man and Chimpanzee, the Prot-simio-human, and the links between this individual and *Procercopithecus* have yet to be found, but we have great doubt if they will show themselves gibbon-like in femoral characters.

If it is reasonable to pass from an orangoid popliteal area through a chimpanzee-like area to a gorilloid area, it does not seem less possible to pass from the orangoid popliteal area to the Neanderthal Type, thence through Galley Hill to the Cromagnon Type, and so (possibly through the Grimaldi Type) to Recent Man. Such a progress, however, marks a slight reversion of Recent Man to a more apelike form, corresponding to what has been already noted in several other femoral characters.

The general conclusion we should draw from this brief examination of the human femoral anomalies is distinctly against such a complex femur as the human having passed at all through such a slender simple form as we must, from our knowledge of the present gibbon and of its fossil representatives, credit the *Prothylobates* with possessing. We feel forced to discard the primate pedigrees of both Haeckel and Dubois, and we reject the hypothesis that the Trinil femur can be a link between those of Primogenial Man and of a *Prothylobates*. If an ancestor of man ever reached a thigh bone in the stage of the Trinil femur, he was, as far as that bone is concerned, Recent Man, and Palaeolithic Man interpolated between two epochs of Recent Man seems incomprehensible[2].

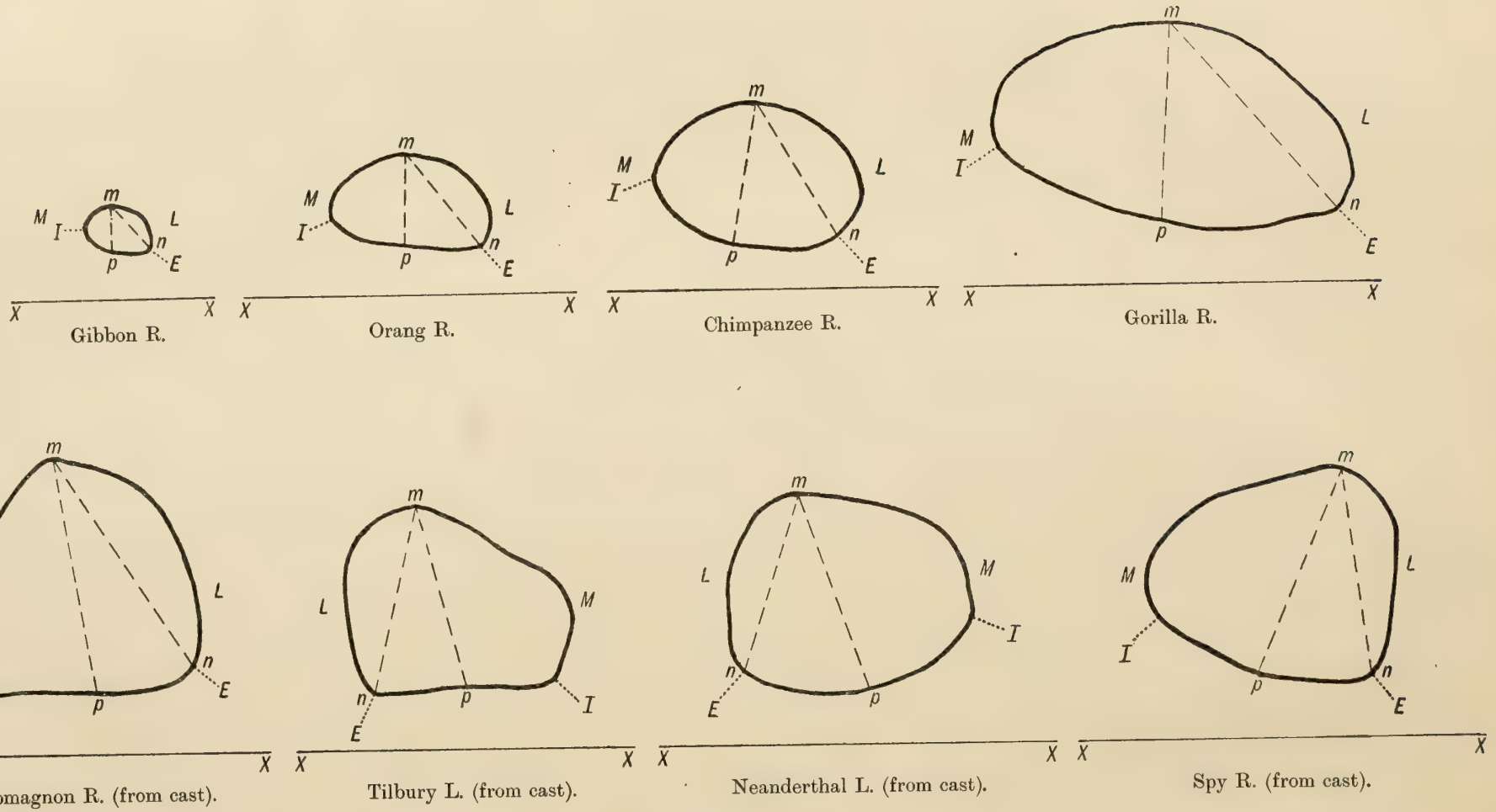
(*b*) *Arguments based on quantitatively measured Characters.* We must now turn to the measurements recorded in our tables of the Anthropoids, Primogenial Man and Recent Man. In the first place we believe that very little weight can be given to absolute size in the question of determining the links of a pedigree. There is no doubt that size decreases as we go backward in the general Simian pedigree, although there are exceptions as the case of recent and fossil gibbons[3]. If the reader

[1] The central trough of the anterior face, which does not usually go as far as the popliteal section, is possibly a vestige of the "tongue" and ultimately of the long patellar articular surface which we find in certain of the lower primates. The extension of this trough on the mesial side of the anterior face is what we note in Primogenial Man; it is emphasised by exaggerated elevation of the lateral side of the anterior face in this region.

[2] The only explanation would be a periodicity in environment in which the essential need of strength alternated with a need for extreme agility.

[3] This degradation tends to confirm the view that the Gibbon evolution has been a continuous one in the direction of increased lightness and agility. A somewhat similar development of the femur is found in *Ateles*. If we look upon the Gorilla as the product of an essential need for strength, and Man as a case in which neither agility nor strength alone has dominated, it need not surprise us to find in the Gibbon certain human features, and we may even accept without much hesitation the statement that *Ateles* is the most human of South American apes. But the pedigree-maker who places *Hylobates* at the base of the anthropoids, might with equal legitimacy claim an *Ateles* as the parent of the *Cebidae*. The simplicity and

Popliteal Sections of Femora of *Homo Primogenius* and Anthropoids

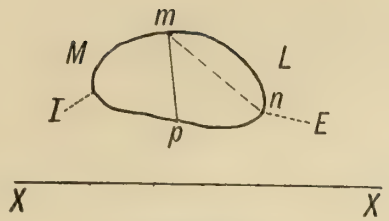


Gibbon R. Orang R. Chimpanzee R. Gorilla R.

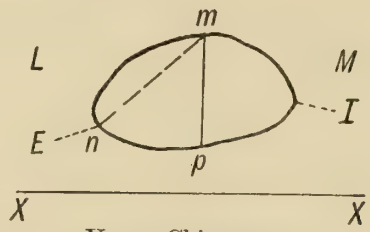
Cromagnon R. (from cast). Tilbury L. (from cast). Neanderthal L. (from cast). Spy R. (from cast).

E and *I*, external and internal supracondylar ridges as closely as they can be determined.
XX is parallel to trace of Standard Vertical Plane on Plane of Popliteal Section ($\frac{1}{10}$ diaphysial length from patellar articular border).

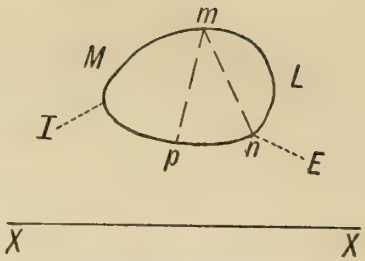
Popliteal Sections of Infant Anthropoids, Primogenial Man and Recent Man



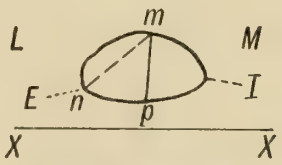
Infant Gorilla.



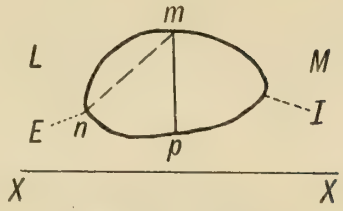
Young Chimpanzee.



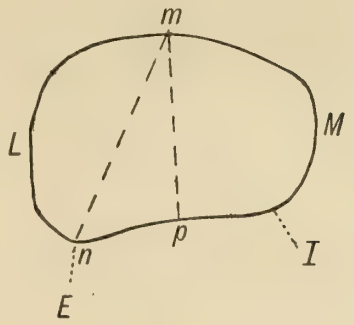
Dryopithecus rhenanus
(Eppelsheimer Femur from cast).

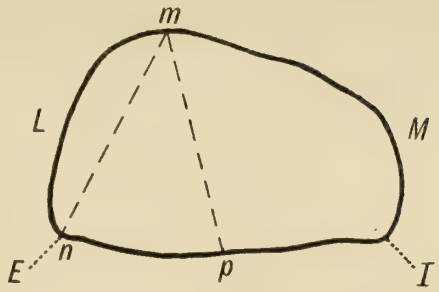


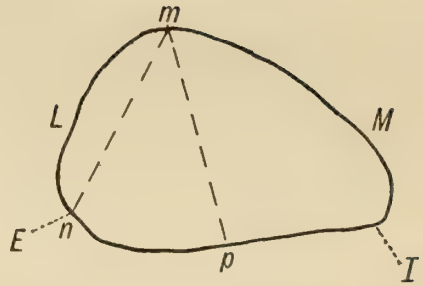
Infant Orang-utan.

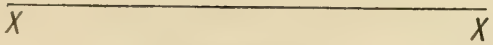


Infant Chimpanzee.

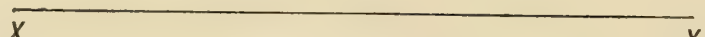




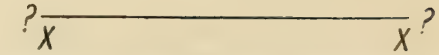




Recent Man.



Galley Hill Man.



Homo mousteriensis (*Hauseri*) (from cast. Note the divergence from Fig. 7, p. 15, where the section was taken by the 4 cms. rule).

E and *I*, external and internal supracondylar ridges as closely as they can be determined.
XX = trace of Standard Vertical Plane on Plane of Popliteal Section ($\frac{1}{10}$ diaphysial length from patellar articular border).

will examine the Plate (LXVI) of the femora of *Dryopithecus rhenanus* and of *Hylobates mülleri*, he will be convinced that mere size does not define a group. The indices of both femora are in striking accordance if the absolute sizes are so different. Again, Plates LXIII and LXIV show anterior and posterior aspects of the femora of Orang, Mousterian Man and a primitive type of Recent Man. The size change from Mousterian Man to Recent Man is not more marked than the size change from Orang to Mousterian Man. A size change alone does not stand as a bar to a close relationship. Two races of dogs which bred intraracially have been true to a *small* femur—the one, if we may say so, orangoid and the other gibbon-like—may when cross bred give rise to a certain number of individuals, with relatively large femora, such as neither breed has exhibited in a long known pedigree. If this can occur in two or three generations, we cannot pay much attention to mere size when dealing with a pedigree extending over thousands of years. Accordingly we propose to deal only with indices in searching for light on the pedigree of man.

The method adopted will be a simplified form of that which we intend to apply to the primates as a whole, except that for simplicity we shall neglect the correlations of the characters dealt with and at certain stages use mean deviations instead of the more appropriate standard deviations. The actual numerical evaluation of position will accordingly be subject to some modifications when the whole of the primates are considered and these simplifications discarded. We consider the following: *Simiadae* and *Hominidae*, Gibbon, *Dryopithecus rhenanus*, Gorilla, Chimpanzee, Orang, *Pithecanthropus erectus*, Neanderthal Man, Recent Man. This may appear at first sight to give an undue numerical superiority to Man, but Neanderthal Man is almost as far removed from Recent Man, as the Gorilla from the Chimpanzee, and although we ourselves look upon *Pithecanthropus erectus, as far as it is represented by the Trinil femur*, merely as an individual case of Recent Man, we feel compelled to give it an individual position because some will not agree with this view. Thus *Pithecanthropus* and *Dryopithecus* differ from the other members of the group in being represented by single bones, and the positions of their species are therefore subject to very large errors, as will be realised by any one conversant with the wide limits of variation in the femur of the same species. It would be absurd, however, to weight *Pithecanthropus* and *Dryopithecus* with one each and Recent Man with 400! We have in each case used male values where they were available and our 17th century Londoners as the most reliable series have been used to represent Recent Man. For each index a mean was found for the eight species, this shall be termed the simio-human mean; further the standard deviation was found of the eight species, in order to obtain a rough measure of the degree of variation in each character. The deviation of each species for each index character from the corresponding simio-human mean was then measured in terms of the corresponding standard deviation. We thus obtain comparable measures of all the characters independent of the degree of variation of the absolute index. We shall term these values *reduced indicial deviations*. If two reduced indicial deviations be

lightness of the femora in both *Hylobates* and *Ateles* are not marks of primitiveness, but of a differentiation dictated by the essential need for agility.

subtracted we obtain what may be termed an *interspecial deviation*. Thus the interspecial deviation for the pithecoid index in Man and the Gorilla is the difference of their pithecoid indices divided by the standard deviation of the pithecoid index in the simio-human group. Further if we take the mean of the interspecial deviations without regard to sign for two species for any set of characters, we obtain what is clearly a reasonable measure of the approximation of these two species for the group of characters in question. We shall term this the *Mean Interspecial Difference* for the group of characters for the two species. A comparison of Mean Interspecial Differences ought to throw considerable light on the degree of resemblance of the femora of various species of Man and apes and by fixing their affinities enable us to see a little further into the simio-human pedigree.

We shall in the investigation occasionally refer to *Tarsius spectrum*, because it has recently been suggested that this species is closer to Man than the Anthropoids.

We take first:

(1) *General Indices of the Femur.*

The following table gives the reduced indicial deviations for the six indices of this group.

SUBTABLE VIII. *Reduced Indicial Deviations. General Indices.*

Index	Simio-human		Gibbon	*Dryopithecus*	Gorilla	Chimpanzee	Orang	*Pithecanthropus*	Neanderthal Man	Recent Man	*Tarsius spectrum*
	Mean	S. D.									
Oblique Direct Lengths Index	99·53	·2947	1·595	·916	·916	−1·459	·238	− ·781	− ·781	− ·611	1·086
Obl. Dir. Troch. Lengths Index	99·76	·3935	·588	·343	·588	1·324	− ·147	−2·108	·098	− ·637	·343
Proximal Breadth Ratio ...	22·32	4·2208	−1·734	−1·118	1·310	− ·040	1·227	− ·289	·659	− ·017	−2·113
Distal Breadth Ratio ...	19·49	3·9053	−1·624	−1·278	1·398	·707	·873	− ·433	·540	− ·190	−2·226
Pithecoid Index	97·44	2·6495	·702	·664	1·287	·966	−1·789	− ·694	− ·279	− ·845	·808
Robusticity of Femur ...	13·81	2·5742	−1·713	− ·587	1·977	·521	·423	− ·431	·190	− ·373	−1·519
Mean Indicial Deviation ...	—		1·326	·818	1·246	·836	·783	·789	·421	·445	1·349
Mean Indicial Deviation having regard to sign			− ·364	− ·177	1·246	·337	·138	− ·789	·071	− ·445	− ·604

This table is of considerable interest; it shows that the Gorilla has all its six indices in excess of the simio-human means, while Recent Man as well as *Pithecanthropus* have *all* their six indices in defect of the simio-human means. Thus for these indices the interpretation of what is "gorilloid" and what is "human-like" is easy—it means excess or defect on the simio-human means. Accordingly if we take the mean individual deviation, *having regard to sign*, we get a rough appreciation of the extent of the human character in the species. Thus Recent Man and *Pithecanthropus* have the maximum human-like values, *Dryopithecus*, *Hylobates* and *Tarsius* are on the human side, Neanderthal Man is nearly a transition form, being slightly gorilloid, while Orang and Chimpanzee are stages to the complete gorilloid character of the Gorilla itself. If we take:

$$\sin\theta = \frac{\text{Mean Indicial Deviation having regard to sign}}{\text{Mean Indicial Deviation}},$$

$\sin\theta$ will lie between -1 for Man and $+1$ for the Gorilla, and θ between $-\frac{1}{2}\pi$ and $+\frac{1}{2}\pi$ will be a reasonable measure for this feature.

If along lines radiating from the "simio-human point" as origin we plot rays r at angle θ, such that $r =$ Mean Indicial Deviation, we obtain a diagram indicating the general nature of the above table.

Diagram A.

General Indices of Femur. Scale 5 mm. = ·1.

If we assume the Simio-human Mean to be a general indication of where the Prot-simio-human is most likely to have been, we see that this form, *as far as the general indices of the femur are concerned*, was far removed from *Hylobates* in either its recent or fossil forms; its nearest resemblance is to Neanderthal Man and then to Recent Man, while the Orang and Chimpanzee are not as far removed as either *Hylobates* or the Gorilla. In other words the suggestion is that the general proportioning of the prot-simio-human femur was far more human than we have hitherto given it credit for being—a Neanderthalloid femur weakened in the orangoid direction. *Tarsius* is as much out of the question as the Gorilla itself.

Let us examine this matter again without any hypothesis as to the simio-human means being a rough measure of the prot-simio-human femur. We can achieve this best by measuring the mean degree of resemblance of the other members of the group to Recent Man, Neanderthal Man and *Pithecanthropus erectus*. The following are the orders of resemblance in these cases as determined by the mean Interspecial Differences.

SUBTABLE IX. *Resemblance of Apes to Man.*

Pithecanthropus erectus		Neanderthal Man		Recent Man	
Recent Man	·394	Recent Man	·573	*Pithecanthropus erectus*	·394
Neanderthal Man ...	·861	Orang	·651	Neanderthal Man ...	·573
Orang	1·292	Chimpanzee	·724	Orang	·898
Chimpanzee	1·352	*Pithecanthropus erectus*	·861	*Dryopithecus rhenanus*	1·070
Dryopithecus rhenanus	1·366	Gorilla	1·175	Chimpanzee	1·072
Hylobates	1·731	*Dryopithecus rhenanus*	1·209	*Hylobates*	1·578
Tarsius spectrum ...	1·755	*Hylobates*	1·716	*Tarsius spectrum* ...	1·603
Gorilla	2·035	*Tarsius spectrum* ...	1·733	Gorilla	1·691

Now these results we venture to think of much interest. The order for *Pithecanthropus* and Recent Man is the same; both are nearer to Neanderthal Man than to any other primate, then come the Orang and Chimpanzee, closely followed by *Dryopithecus rhenanus* and then with much smaller degree of resemblance by Recent Gibbon, *Tarsius* and the Gorilla. *Tarsius* is nearly twice as remote from Recent Man as the Orang for the General Indices of the femur. The Trinil femur is seen to be widely divergent from that of *Hylobates*; it exhibits no more deviation from Recent Man than any individual recent femur might do and it is closer to Neanderthal Man and then to the Orang and Chimpanzee than to fossil or Recent Gibbon.

In the case of the Neanderthal Type, it is closest to Recent Man, but it resembles the Orang, Chimpanzee and the Gorilla (owing to its more marked gorilloid features) very much closer than Recent Man does. In fact our results are in good agreement with our previous method of approach and confirm the view that for these General Indices, we must look for a human ancestral femur more of the Orang-Chimpanzee Type than of the *Hylobates* Type.

The reader may be interested in seeing the order of the Mean Interspecial Differences for *Tarsius*.

Hylobates	·339
Gorilla	·497
Dryopithecus rhenanus	·532
Recent Man	1·603
Neanderthal Man ...	1·716
Pithecanthropus erectus	1·755
Chimpanzee	1·788
Orang	2·053

It is difficult to note in this order any special relation of *Tarsius* to Recent or Palaeolithic Man. It seems rather to mark the relative distances the *Anthropoidea* have travelled from an original lemuroid stock; in the General Indices of the femur

the Gibbon is *five* times as close as Man is to *Tarsius*. The appearance of certain lemuroid features as anomalies in the human femur—third trochanter lateral projection, frontal pilaster—which we are not familiar with in Orang and Chimpanzee, may even justify the greater remoteness of these apes from *Tarsius*.

(2) *Indices of the Shaft.*

We proceed in precisely the same way as for the General Indices, forming first the Table of Reduced Indicial Deviations.

SUBTABLE X. *Reduced Indicial Deviations. Indices of the Shaft.*

Index	Simio-human Mean	Simio-human S.D.	Gibbon	*Dryopithecus*	Gorilla	Chimpanzee	Orang-utan	*Pithecanthropus*	Neanderthal Man	Recent Man	*Tarsius spectrum*
Platymeric Index	84·52	5·9775	– ·137	1·168	·189	– ·120	– 1·643	1·586	– 1·158	·113	·624
Pilastric Index	96·81	11·6886	·971	·128	– 1·276	– 1·199	– 1·259	1·016	·966	·654	1·623
Popliteal Index	70·76	10·7716	·690	– ·674	– 1·824	– ·233	– ·451	1·683	·802	·008	3·326
Index of Popliteal Skewness	102·98	15·2982	– ·234	– 1·503	1·976	·276	– ·031	—	·302	– ·787	1·118
Soffit Index	50·85	5·8568	– 1·178	1·784	1·408	– ·222	·009	– ·794	– ·862	– ·145	– 1·135
Index of Gracility (Upper)	90·06	7·7460	– 1·124	– ·382	1·754	1·115	·676	– ·899	– ·989	– ·156	– ·873
Index of Gracility (Lower)	73·48	3·4346	1·593	– 1·188	– ·984	·515	·763	·938	– ·926	– ·708	6·281
Index of Trans. Slenderness	8·34	2·1381	– 1·562	– ·673	1·875	·800	·870	– ·627	– ·253	– ·416	– 1·632
Index of Sagittal Slenderness	7·86	1·2589	– 1·954	– ·683	1·779	·349	·429	– ·207	·429	– ·127	– 1·795
Index of Proximal Taper ...	97·86	5·9832	– ·444	1·243	·575	·750	– ·378	1·026	– 1·781	– ·996	– 1·330
Index of Distal Taper ...	99·28	7·8871	– ·987	– 1·189	– 1·253	1·302	·814	·941	·789	– ·422	– ·644
Primary Index of Bowing ...	2·22	1·2857	– 1·843	– 1·260	·996	·568	– ·327	·451	1·151	·257	– 2·699
Mean Indicial Deviation ...	—		1·060	·990	1·324	·621	·6375	·924	·867	·399	1·923
Mean Indicial Deviation paying attention to sign ...			– ·517	– ·269	·435	·325	– ·044	·426	– ·1275	– ·228	·2387

The results of this table are again of considerable interest. Forming $\sin\theta$ = Mean Indicial Deviation having regard to sign/Mean Indicial Deviation and deducing θ we have prepared a diagram as before.

We see again that Recent Man is nearer than any anthropoid to the Simio-human Mean. Instead of *Pithecanthropus* and Neanderthal Man coming next we find the Orang and Chimpanzee have replaced them, the orders being:

Orders of Mean Indicial Deviations.

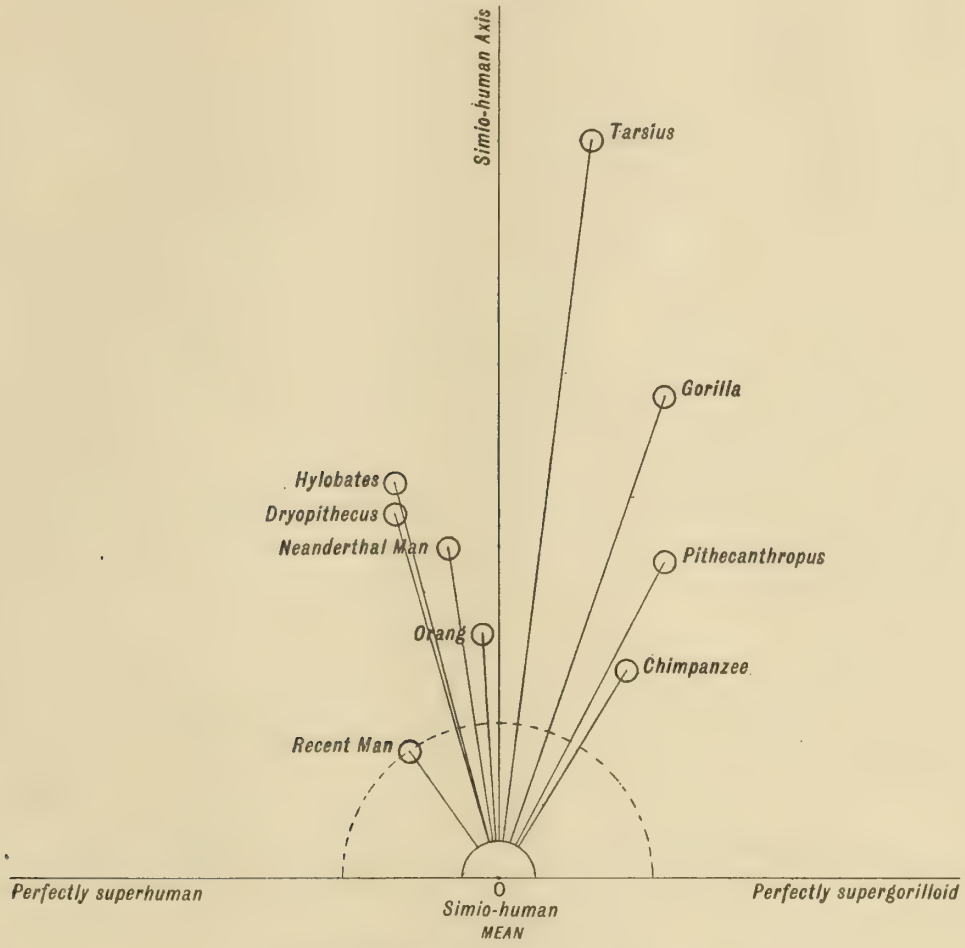
General Indices of Femur		Indices of Shaft	
Neanderthal Man ...	·421	Recent Man	·399
Recent Man	·445	Chimpanzee	·621
Orang-utan	·783	Orang-utan	·637
Pithecanthropus erectus	·789	Neanderthal Man ...	·867
Dryopithecus rhenanus	·818	*Pithecanthropus erectus*	·924
Chimpanzee	·836	*Dryopithecus rhenanus*	·990
Gorilla	1·246	*Hylobates*	1·060
Hylobates	1·326	Gorilla	1·324
Tarsius spectrum ...	1·349	*Tarsius spectrum* ...	1·923

Now the General Indices are of course largely dependent on the shape of the shaft and these two orders indicate that the Gorilla and the Recent Gibbon have the

least shaft resemblance to the mean simio-human shaft. They may be reasonably supposed therefore to have developed furthest from the prot-simio-human form. The fossil Gibbon (*Dryopithecus rhenanus*) is nearer than the Recent Gibbon to the Prot-simio-human, but it is clearly on the whole the Orang-utan and Chimpanzee shafts which follow the several human types in approximating to the Simio-human Mean.

Examining the table we note that there are for the indices of the shaft no individuals with all their indices less than those of the Mean Simio-human, and no

Diagram B.



Indices of Shaft. Scale 5 mm. = ·1.

individual with all its indices greater. Thus we cannot call the lines at $\theta = \pm 90^\circ$ the Axes of perfect human and perfect gorilloid characters, because Man and the Gorilla no longer lie upon them. Still it may be convenient to speak of them as the perfect "supergorilloid" and the perfect "superhuman" axes, the initial line for the measurement of θ being the perfect simio-human axis. In the case of both the general and the shaft index charts the Orang is closest to this simio-human axis; and for the Indices of the Shaft the *Hominidae* and *Anthropoidea* diverge less than is the case for the General Indices from the perfect simio-human axis towards the perfect super-

human and supergorilloid axes. The position of *Pithecanthropus* is somewhat anomalous, but then this position is probably due to the measurements being those for a single individual, and one for which the measurements are at present largely guess-work.

We now turn to the second method of looking at the problem and measure the degree of resemblance of Recent Man, Neanderthal Man and *Pithecanthropus erectus* to the other individuals of the group.

We have the following orders:

SUBTABLE XI. *Mean Interspecial Differences of Men and Apes.*

Pithecanthropus erectus		Neanderthal Man		Recent Man	
Chimpanzee	·930	.Recent Man	·737	Neanderthal Man ...	·737
Neanderthal Man ...	·942	*Pithecanthropus erectus*	·942	*Dryopithecus rhenanus*	·912
Recent Man	·947	Orang-utan	1·046	*Pithecanthropus erectus*	·947
Dryopithecus rhenanus	1·149	Chimpanzee	1·101	Chimpanzee	·953
Orang-utan	1·206	*Hylobates*	1·204	Orang-utan	·968
Hylobates	1·435	*Dryopithecus rhenanus*	1·575	*Hylobates*	1·024
Gorilla	1·660	Gorilla	1·749	Gorilla	1·473
Tarsius spectrum ...	1·995	*Tarsius spectrum* ...	1·893	*Tarsius spectrum* ...	1·816

We see from these results that the Chimpanzee and the Orang are nearest of the existing Anthropoids to any form of Man—considerably nearer than the Gibbon or Gorilla. *Tarsius* stands well outside all the Anthropoids and has no close resemblance of any kind to the simio-human group. On the other hand the Eppelsheimer femur—as far as the shaft is concerned—resembles the human femur closer than the Trinil femur and is only excelled by that of Neanderthal Man. This was not, however, true for the General Indices of the femur.

(3) *Indices of the Bust.*

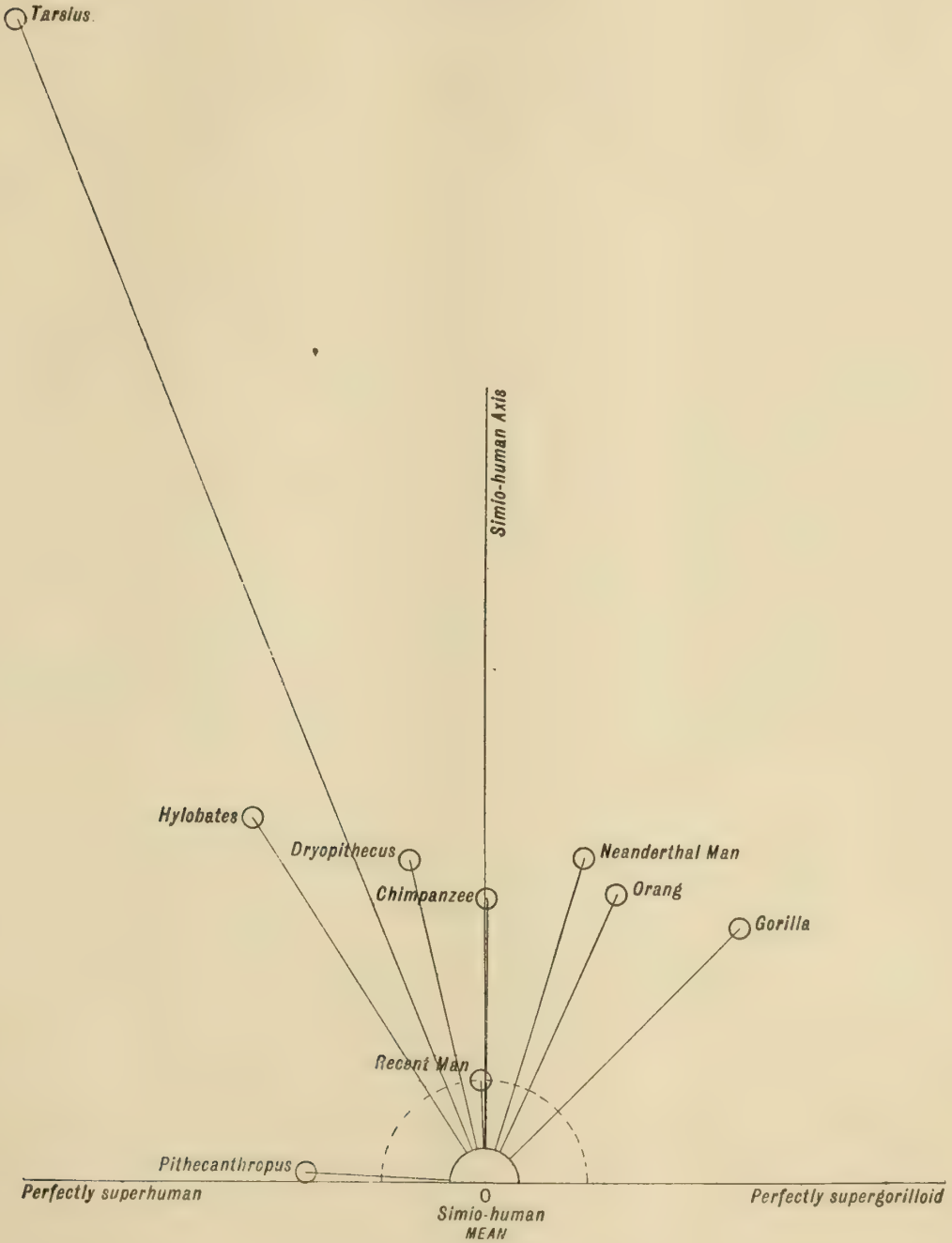
We now turn to consider how far these orders are confirmed, if we take into account the shape of the epiphyses as well as that of the diaphysis.

SUBTABLE XII. *Reduced Indicial Deviations. Indices of Bust.*

Index	Simio-human Mean	Simio-human S. D.	Gibbon	*Dryopithecus*	Gorilla	Chimpanzee	Orang-utan	*Pithecanthropus*	Neanderthal Man	Recent Man	*Tarsius spectrum*
Robusticity of Head ...	21·77	4·0143	−1·549	−1·263	1·452	·356	·904	−·516	·805	−·192	−2·437
Ellipticity of Head ..	99·32	·8757	1·576	·320	·263	·948	·206	−1·736	−1·051	−·537	10·027
Ellipticity of Neck ...	78·53	4·3153	−·656	1·522	·039	−·285	−1·351	—	1·383	−·656	−4·722
Secondary Index of Neck	53·13	5·7647	−·552	1·157	·324	−·803	−1·723	—	1·227	·368	·108
Lemotic Index	12·44	2·0519	−1·408	−·779	1·735	·858	·955	−·507	−·653	−·190	−3·747
Head Bust Ratio ...	61·08	4·8514	−·604	−1·191	−·058	−·645	·107	−·058	2·395	·045	3·147
Primary Bust Ratio ..	17·81	2·8854	−1·529	−·939	1·730	·707	·967	−·523	−·211	−·194	−3·521
Secondary Bust Ratio ...	17·96	2·8955	−1·575	−·953	1·689	·722	·946	−·539	−·090	−·211	−3·596
Bust Shaft Index ...	21·09	4·0430	−1·543	−·962	1·499	·781	1·190	−·591	−·220	−·146	−3·227
Capital Ratio	10·87	1·9870	−1·570	−1·243	1·475	·317	·921	−·488	·770	−·186	−2·577
Capito-bicondylar Ratio	57·69	2·5585	·668	·277	−1·051	−2·145	·942	·004	·786	·473	−1·598
Epiphysial Ratio ...	95·26	6·8192	1·142	1·516	−·625	−·771	·343	−·053	−1·797	·240	−3·659
Mean Indicial Deviation	—		1·181	·928	·995	·778	·880	·502	·949	·287	3·531
Mean Indicial Deviation paying attention to sign ...			−·633	−·213	+·706	+·003	+·367	−·501	+·279	−·099	−1·317

We obtain exactly as before a diagram for the Indices of the Bust. We see that Recent Man and *Pithecanthropus* are nearest to the Simio-human Mean, then follow Chimpanzee and Orang, and even *Dryopithecus* is interpolated between these and Neanderthal Man, and is almost as remote as the Gorilla. *Hylobates* is most removed, while *Tarsius* in degree of close resemblance to anthropoids and men is an *affaire pour*

Diagram C.



Indices of Bust. Scale 5 mm. = ·1.

rive. If we could suppose that the simio-human mean in any way represents an ancestor of the simio-human group this diagram would go far to confirm the opinion held by some that Neanderthal Man was not a direct ancestor of Recent Man.

Turning to the mean interspecial differences we have the following resemblance orders for the bust:

SUBTABLE XIII. *Mean Interspecial Differences of Men and Apes.*

Pithecanthropus erectus		Neanderthal Man		Recent Man	
Recent Man	·411	Recent Man	·895	*Pithecanthropus erectus*	·411
Dryopithecus rhenanus	·803	*Pithecanthropus erectus*	·952	Neanderthal Man ...	·895
Neanderthal Man ...	·952	*Dryopithecus rhenanus*	1·296	Orang-utan	·930
Hylobates	1·174	Orang-utan	1·417	*Dryopithecus rhenanus*	·964
Orang-utan	1·250	Chimpanzee	1·487	Chimpanzee	1·017
Chimpanzee	1·404	Gorilla	1·517	*Hylobates*	1·070
Gorilla	1·636	*Hylobates*	1·840	Gorilla	1·227
Tarsius spectrum ...	3·009	*Tarsius spectrum* ...	3·567	*Tarsius spectrum* ...	3·496

The close relation in the femoral bust of Recent Man and *Pithecanthropus erectus* is again brought out—the resemblance is double that of either to Neanderthal Man. The Gorilla is remote, as remote as *Hylobates*, to Recent or Primogenial Man. The Orang and Chimpanzee are closer than Gorilla and *Hylobates*. The position of the Eppelsheimer femur deserves again a word of comment. We ought not to compare its position in the series with that of the Orangs and Chimpanzee *directly*. They are "recent," and a sort of proportional sum ought to be worked out mentally, *i.e.* as the position of the fossil Gibbon *Dryopithecus rhenanus* is to the position of the Recent Gibbon, such would be the position of the fossil Chimpanzee or Orang—if we had either—relatively to the Recent Chimpanzee or Orang. Only such a proportional change could place the Orang-Chimpanzee relationship to Man in its fitting position[1]. Notwithstanding the position of *Dryopithecus rhenanus* we must refuse to place the Gibbon in a closer relation to Man than the Orang and Chimpanzee.

(4) *The Indices of the Distal Epiphysis.*

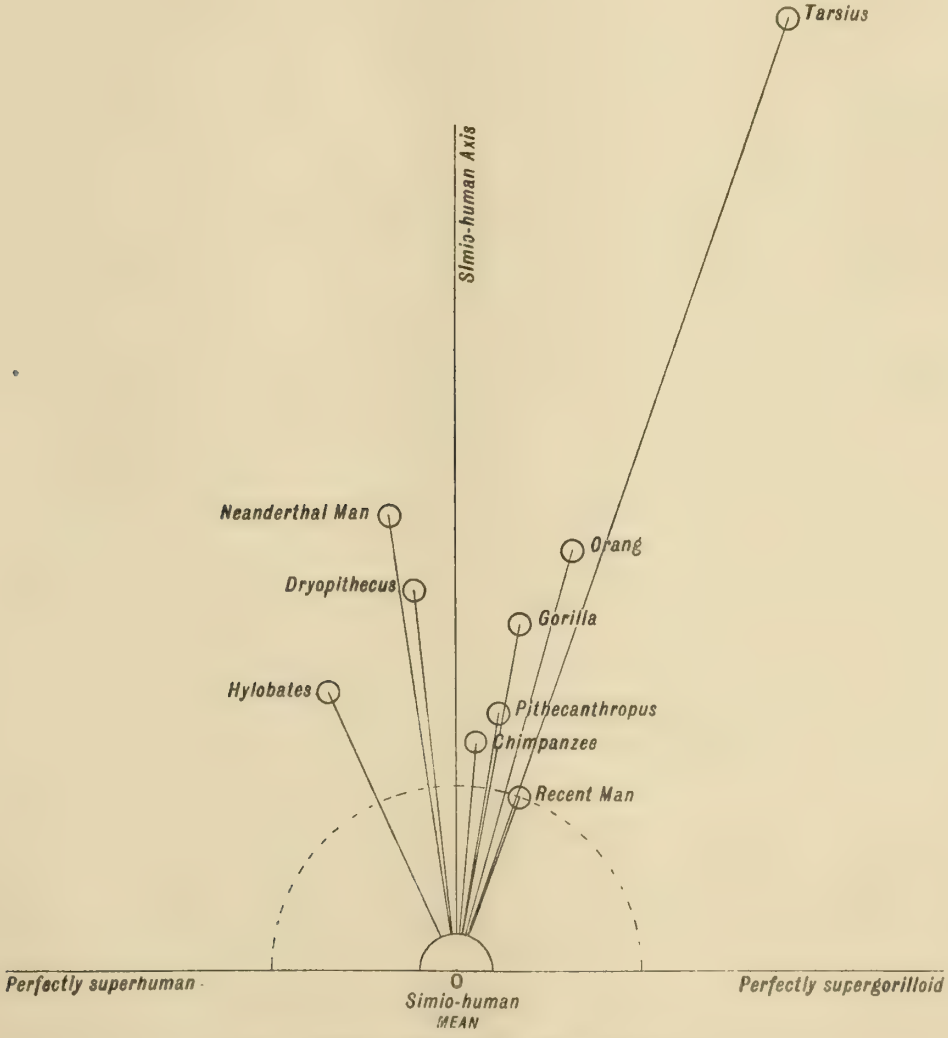
If we examine our separate tables we see that Recent Man is nearest to the Simio-human Mean in the characters of the bust, is most remote in the characters of the distal epiphysis and that the characters of the shaft and the general indices are intermediate. In other words the characters of head and neck in the human femur are probably most primitive and those of the distal epiphysis most developed. This is in accordance with our discussion of the patellar articular surface (see p. 424 *et seq.*). It is of special note that the Chimpanzee after Man has changed least from the Simio-human Mean. The Orang for this region of the femur has developed even more than

[1] We have little hesitation in asserting that if a fossil Chimpanzee femur were found it would be much closer to the human femur than that of the Recent Chimpanzee. Having measured many thousands of teeth in various races of Man, we believe that possibly too little stress has been laid on the range of the variation and too great stress on teeth differences in classifying fossil primates isolated by mandible fragments. The discovery of a fossil femur of *Palaeopithecus sivalensis* or of *Sivapithecus indicus* would be of intense interest.

SUBTABLE XIV. *Reduced Indicial Deviations. Indices of Distal Epiphysis.*

Index	Simio-human Mean	Simio-human S. D.	Gibbon	*Dryopithecus*	Gorilla	Chimpanzee	Orang-utan	*Pithecanthropus*	Neanderthal Man	Recent Man	*Tarsius spectrum*
Condylar Index	72·47	7·8120	·247	·375	−1·596	−1·257	·739	·925	1·322	·721	6·033
Condylar Lengths Index	93·98	10·3082	·012	·904	−1·278	− ·949	−1·240	·312	1·622	·618	·526
Bicondylar Ratio ...	18·96	3·8088	−1·552	−1·224	1·612	·536	·851	− ·410	·483	− ·291	−2·156
Band-radial Index ...	99·25	8·8276	− ·164	− ·493	− ·051	− ·227	−1·875	1·445	− ·074	1·439	−3·212
Condylar Trochant. Index	13·88	2·4644	−1·818	−1·209	·353	·028	·576	·130	1·631	·312	− ·398
Distal Articulation Ratio	16·63	3·3686	−1·449	−1·286	1·713	·570	·941	− ·187	− ·039	− ·261	−2·117
Distal Articulation Index	88·09	4·4593	·361	− ·491	·226	− ·883	1·168	1·235	−1·948	·327	·081
Rotular Ratio	6·27	1·2889	− ·442	·256	·877	·722	1·575	− ·753	−1·800	− ·403	2·273
Rotular Index	37·90	7·6184	1·366	1·274	− ·656	·112	·538	− ·657	−1·825	− ·151	7·727
Diaphysial Rotular Ratio	7·34	1·7750	− ·501	− ·417	·823	·710	1·893	− ·699	−1·487	− ·332	1·837
Mean Indicial Deviation	—		·791	·993	·919	·599	1·140	·675	1·223	·486	2·636
Mean Indicial Deviation paying attention to sign ...			− ·328	− ·109	+ ·169	·053	+ ·307	+ ·112	− ·176	+ ·165	+ ·883

Diagram D.



Indices of Distal Epiphysis. Scale 5 mm. = ·1.

the Gorilla, while exceptionally *Hylobates* is more primitive than *Dryopithecus rhenanus* and Neanderthal Man.

Diagram D (p. 497), drawn up in the same manner as before, illustrates all these points effectively, while we note that for the distal epiphysis the development of Recent Man is on the supergorilloid and not the superhuman side of the perfect Simio-human axis. This position is undoubted, although exceptional, and somewhat disconcerting from the standpoint of nomenclature.

The following are the relative orders for the mean interspecial differences of the characters of the distal epiphysis :

SUBTABLE XV. *Mean Interspecial Differences, Men and Apes.*

Pithecanthropus erectus		Neanderthal Man		Recent Man	
Recent Man	·302	Recent Man	1·193	*Pithecanthropus erectus*	·302
Hylobates	1·035	*Pithecanthropus erectus*	1·195	*Hylobates*	·902
Dryopithecus rhenanus	1·128	Chimpanzee	1·529	*Dryopithecus rhenanus*	·903
Neanderthal Man ...	1·195	*Dryopithecus rhenanus*	1·556	Chimpanzee	1·079
Chimpanzee	1·269	*Hylobates*	1·751	Neanderthal Man ...	1·193
Gorilla	1·391	Gorilla	1·843	Gorilla	1·266
Orang	1·555	Orang	2·136	Orang	1·597
Tarsius spectrum ...	2·928	*Tarsius spectrum* ...	3·467	*Tarsius spectrum* ...	2·746

Now this subtable shows remarkable relations. While in the characters of the bust both Primogenial and Recent Man are further removed from *Hylobates* and the Gorilla, in the characters of the distal epiphysis the Orang is most remote. The greatest resemblance in Recent Man is actually to *Hylobates* and *Dryopithecus*. Even the Chimpanzee comes before Neanderthal Man. Thus Recent Man is distinctly gibbon-like in the distal epiphysis, but it must be remembered that it is precisely in the characters of the distal epiphysis that Recent Man has travelled furthest from the simio-human mean. It is exactly the same with *Pithecanthropus*, it is in distal epiphysis closer to the Gibbon than to the Greater Anthropoids[1]. Only in the case of Neanderthal Man does the Chimpanzee come by its own again and displace the Gibbons. Clearly the Orang for the distal epiphysis has had a very individual evolution, which has carried it far from man as well as from the simio-human mean.

So far as we are aware no claim to a gibbon-like ancestor for man has been based on any close resemblance of the distal epiphysis in Recent Man and the Gibbon, but it is we think the one region of the femur upon which such a relationship could be based.

(5) *Relationships on the Basis of the combined forty Femoral Indices.*

As the different regions of the femur do not give wholly concordant results—an occurrence which might well be anticipated with divergent lines of evolution—we

[1] It tends of course to confirm the result for Recent Man, but we can never lay very great stress on results for a single femur, knowing how femoral characters vary, and that in no case is *Pithecanthropus* like an individual gorilla quite outside the human range of variation. Added to this we have the great uncertainty of the determination of nearly every measurement in the case of the Trinil femur.

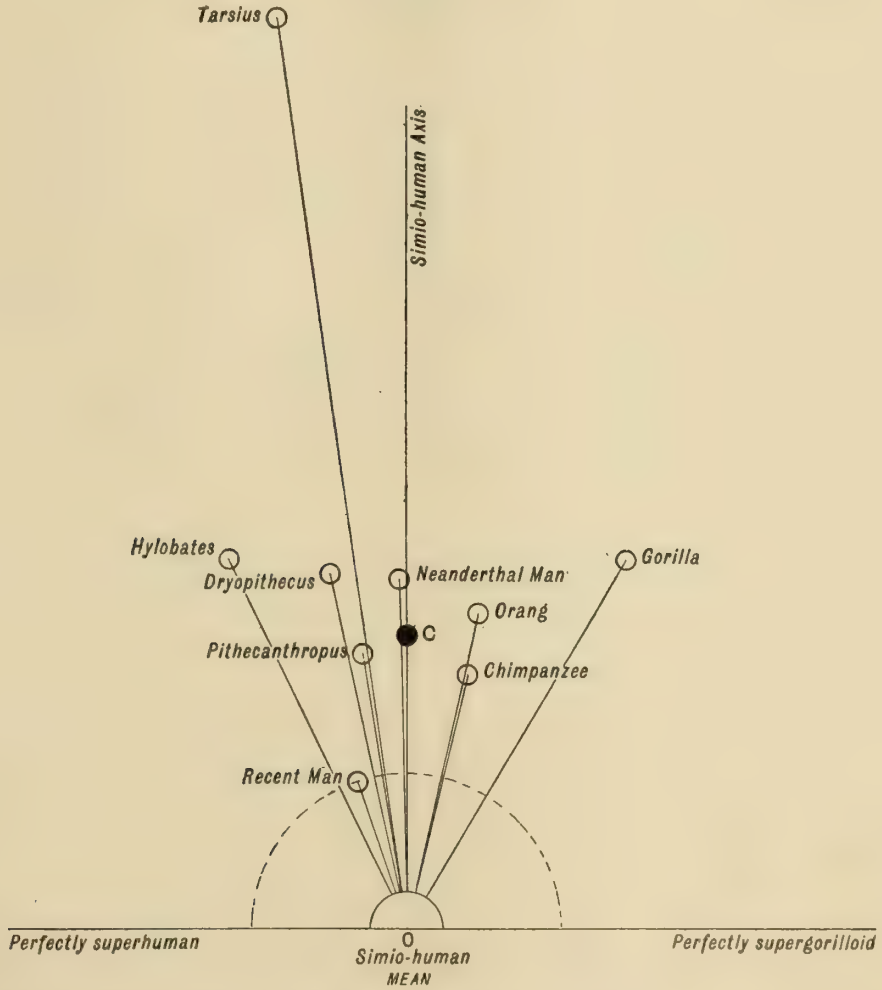
think it desirable to discuss the conclusions which flow from a consideration of the shape of the femur as a whole, *i.e.* when we pool our forty indicial characters.

SUBTABLE XVI. *Mean Indicial Deviations for forty Femoral Characters.*

	Gibbon	*Dryopithecus*	Gorilla	Chimpanzee	Orang-utan	*Pithecanthropus*	Neanderthal Man	Recent Man	*Tarsius spectrum*
Mean Indicial Deviation ...	1·069	·946	1·112	·695	·858	·715	·914	·394	2·498
Mean Indicial Deviation paying attention to sign	− ·4816	− ·1984	+ ·5715	+ ·1622	+ ·1944	− ·1128	− ·0119	− ·1236	− ·3635
θ	− 26° 47′	− 12° 6′	+ 30° 55′	+ 13° 30′	+ 13° 6′	− 9° 5′	− 0° 45′	− 18° 17′	− 8° 22′

The order of approach to the perfect Simio-human femur would be measured by the smallness of the radius vector and the smallness of the angle from the vertical of the following diagram.

Diagram E.



General Diagram giving the results for forty femoral indices. C is the vector mean.
Scale 5 mm. = ·1.

SUBTABLE XVII. *Order of Mean Indicial Deviations.*

Recent Man	·394
Chimpanzee	·695
Pithecanthropus erectus ...	·715
Orang-utan	·858
Neanderthal Man	·914
Dryopithecus rhenanus ...	·946
Hylobates	1·069
Gorilla	1·112
Tarsius spectrum	2·498

Now the results which flow from the above general order are of very great interest, and the reader must give to them the weight due to an analysis based on forty separate indices:

(i) Recent Man is by far the closest of any member of the group to the Simio-human mean.

(ii) The Gibbon and the Gorilla are furthest removed.

(iii) The Chimpanzee and the Orang are nearest of the anthropoids to the Simio-human mean. If we regard the fossil gibbon, *Dryopithecus*, as nearer by 100 points in the 1000 to that mean than the recent gibbon we might anticipate that the ancestors in like stages of the Chimpanzee and Orang would be about 50 per cent. and 100 per cent. respectively more divergent than Recent Man from the Simio-human mean.

Thus just as *Dryopithecus* draws in for both radius vector and angle on recent *Hylobates*, we should anticipate that the ancestors of Orang and Chimpanzee would draw in for both radius and angle on their modern representatives and so place themselves close to the perfect Simio-human axis, and so to speak within the region mapped out by a curve through the points occupied by Neanderthal Man, *Pithecanthropus* and Recent Man.

The conclusion seems forced upon us that:

(iv) The femur of the primitive Simio-human was probably more human than it has been given credit for. It was a human femur modified by a chimpanzee and to a less extent by an orang character. It was remote from the Recent Gibbon and the existing Gorilla, although naturally it would be somewhat nearer to their fossil ancestors.

This fundamental result appears to be absolutely in accord with the independent conclusion we were driven to by a consideration of the anomalies of the femur—they pointed in the direction of the Chimpanzee and not in that of a gibbon-like ancestor (see our pp. 479—485), still less in that of a gorilloid ancester.

We have given direction to our deviation from the Simio-human mean, by considering whether an individual in the group had excess or defect in the average of indices over the Simio-human mean. If we now take the centroid or mean of our *localised* points, it falls at the point marked *C* on the perfect Simio-human axis. It is somewhat in the direction of this localised mean, that we should anticipate the

ancestors of Neanderthal Man, *Pithecanthropus erectus*, Orang and Chimpanzee closing in. This Simio-human centroid—to distinguish it from the purely numerical simio-human mean—is interpolated between Neanderthal Man and Recent Man, and is on the other side of *Pithecanthropus* to the Gibbons.

(v) *Final Problems.*

Two problems therefore suggest themselves, which may be discussed, if they cannot be answered on the basis of our present material and knowledge.

In the first place the femur of Recent Man may be described as "primitive" if by this we denote that it is quantitatively nearest of all to the simio-human mean. So far we are to a certain extent in agreement with Professor Wood-Jones, but this "primitiveness" is not that at any rate of the femur of *Tarsius*. Nor is it in the direction of the relative simplicity of the femur of the Gibbon; the primitiveness demands something of the robustness and complexity of the human and Chimpanzee femora.

But this is to be borne in mind:—if we go back to the primitive Simio-human we shall find that if his femur has not changed as much as some have anticipated from the human, his skull will certainly have changed to a far more simian type. Can it therefore be that the combination of the very simian skull cap of *Pithecanthropus* with the very human femur which has been associated with it fulfils the essential conditions suggested by our investigation of the Simio-human indices? In the course of this work we have come across no character of the Trinil femur which could not be considered as human, and what is more falling well within the range of individual variations of Recent Man. But what if all these characters are not only human, but prot-simio-human? The answer to this problem must not be lightly given. There have been two opposed schools of opinion with regard to the Trinil femur, one asserts that it is purely a human femur, and with this we agree—and the other finds reasons which convince its supporters, but which we fail to appreciate, for its being the femur of an ape—in particular of a gigantic gibbon. It would be a strange turning of the tables, if the former school had really been arguing in favour of a close relation between *Pithecanthropus* and the Prot-simio-human! Now we consider that in no case does the Trinil femur outrun the range of character variations which occur in human femora, but in every long series of human femora it is possible to note some that are more gibbon-like than the average and others which for want of a better word may be termed more gorilloid. The Trinil femur belongs to the former group, but it is not as far as we can discover more gibbon-like than many human femora. These gibbon-like variations would not be anything extraordinary in a recent human femur, but if the Trinil femur is to be taken as approximating to the primitive simio-human type we consider that they become far more improbable, *because we see strong arguments against a gibbon-like ancestor for the simio-human group. On the contrary we should expect the prot-simio-human femur to have human plus chimpanzee and not plus gibbon features.*

Such an ancestral line leads us to a muscular rather massive, bowed and fossed femur, and not to the straight, slender unfossed gibbon form. We are moving in the

direction of the *Cercopithecidae* and the Lemuroids, and the Gibbon has specialised in a wholly different direction. That the Trinil femur is closer to *Hylobates* in the characters of its distal epiphysis than to *Dryopithecus* is not in its favour as a prot-simio-human femur; it is in our opinion directly against it[1]. We need to approach closer rather than to recede further from a link with chimpanzee characters. Granted a gibbon-like ancestor, we have to account for the appearance in the human femora of the marked robusticity, the considerable bowing, the increased obliquity, the hypotrochanteric fossa, and the third trochanter. Why have they disappeared in the Gibbon to reappear again in Man? We need a chimpanzee-like stage to link up our prot-simio-human with the like types among the lesser apes.

Hence although the strength of the human features of the Trinil femur—which has been so manifested in the course of our investigations in the last chapter—is not so markedly against the claims made for the Trinil femur as one school has considered, the very gibbon characters claimed for it by the opposite school, which to a moderate extent we admit to exist, appear to us to disqualify it as the femur of a forbear of Man. Its claim to that must be based entirely on its human attributes and not on its gibbon-like features.

Now this first problem raises indeed our second problem. If the Trinil femur represents the true femur of a Prot-simio-human, then we think it would be necessary to accept the position of a double origin of man. The transition from the Trinil femur to the femur of Recent Man could hardly have been made by way of the femora of Neanderthal type. We can scarcely suppose that man sunk after the Trinil stage to such a bowed pilasterless form, and then largely reverted to the Trinil type.

If the marked human pilaster did not owe its introduction to the later Cromagnon type, but a pilaster existed even in the Prot-simio-human, we look in vain for its source. Only the slightest traces of it can be found in the Gibbon and it exists in no marked form in the lesser apes. If we stick to the solid ground of the first *marked* appearance of the pilaster in the Cromagnon type, then its pilasterless predecessor may be easily predicted to have been a robust and bowed, because pilasterless form; a form also which would have more marked frequency of the anomalies of the human femur—and the Neanderthal type suits closely the necessities of the case. But the Neanderthal femur requires behind it not another Recent Human femur, not a gibbon-like femur, not even a *Dryopithecus* femur—unless it were largely strengthened by chimpanzee-like features—but what, for a better descriptive name, we may term a troglodytic femur.

We find it very difficult to place a Cromagnon-like type in the direct line of man's ancestry (in order to introduce the essential pilaster) and at the same time not to demand an extremely robust, if pilasterless, femur behind Cromagnon, *i.e.* a femur of practically Neanderthal type. Such is our reason for placing the Neanderthal femur at least close to the main human line, and with this as linkage a return to such a recent man type as the Trinil femur seems unreasonable. Back of the Neanderthal

[1] The reader should not forget meanwhile the essentially important point also that it is more than three times closer to Recent Man than to *Hylobates*!

type the robusticity has to be partly lost as we approach the Prot-simio-human, and we can see something of this disappearance in the femur of the Chimpanzee. Less the pilaster this prot-simio-human femur was possibly more recent manlike in its indices than its successors, the Neanderthal and Cromagnon types, to which Recent Man is indebted for robusticity and pilaster through transitional exaggerated types. We do not state this as dogma, but it appears to us a more reasonable hypothesis *as far as evidence based on a single bone is concerned* than any theory which links up Man with gibbon-like forms relatively recently, and places the link with the greater *Simiinae* at a far greater distance. If such an arrangement be correct we have to suppose that features which are frequent anomalies in the recent human femur and almost special characters of *Homo neanderthalensis*, and which both share with the greater anthropoids, were independently developed in two distant primate lines. Such a character as the hypotrochanteric fossa in Recent Man exhibits all the signs of a disappearing phenomenon becoming less and less frequent since palaeolithic times. It is more reasonable to suppose it as a vestige of what was once a generic character—even as the lateral protrusion of the anterior face in modern man is a vestige of a lemuroid generic character—than to suggest its independent development in two or even more simio-human lines proceeding from a gibbon-like origin[1].

Venturesome as it may appear to many for the biometrician to enter this field we cannot refrain from a strong opinion that gibbon-like forms lie off the main line of simio-human ancestry, and that accordingly the old pedigrees of the Primates—such as that of Haeckel—and the more modern ones—such as those of Dubois and Pilgrim—need serious modification when judged by the metrical relationships of the femora of the Primates.

We put forward as a working hypothesis that the prot-simio-human femur was not a simple, straight, slender femur—a hylobatic femur developed for lightness and agility—but a troglodyte femur, robust, fossed for muscular attachments, and bowed,

[1] This criticism, of course, applies to Pilgrim's suggested Evolution of Man and the Anthropoids (Bibl. 118 *bis*, Chart and text). That scheme is largely based on a study of the teeth, often individual teeth, and portions of the jaws. We venture to think the certainty of teeth inferences will be somewhat weakened when longer studies have been published on the dental variations existing within a single species. We should also know better where we stand, if a fossil femur had been found, which could be definitely associated with any of the now very numerous named fossil primates known at present only by teeth or jaw fragments; there are probably more than a dozen such fossil primates. The one femur of the kind which exists is the Eppelsheimer femur. Its indices place it undoubtedly in the gibbon-like class. Yet in Bronn's *Thier.-Reich* (Bd. VI. Abth. V. Bd. I. S. 594) it is spoken of as *Dryopithecus*, and quite recently Abel (Bibl. 87 *ter*) terms it *Dryopithecus rhenanus*, and Bumüller (Bibl. 81) also classifies it in the same manner. If *Dryopithecus* had a femur of this character and the propliopithecine ancestors of man a similar one then the appearance of common characters in Recent Man, Neanderthal Man, Chimpanzee, Gorilla and Orang, cut off by such ancestry from each other and from the *Cercopithecidae*, is a stiff proposition. Even if we assume the Eppelsheimer femur to be pliohylobatic, and the *Dryopithecus* femur to have had a more troglodyte character, then the femur of Recent Man for the one part, the femur of Neanderthal Man for the second part, and the femur of *Dryopithecus* as ancestor of the greater anthropoids for the third part, will still be separated by Pilgrim's scheme from kindred forms in the *Cercopithecidae* by a gibbon-like ancestry possessing little or nothing of the troglodyte features of great robusticity, marked fossing and exaggerated bowing.

but without pilaster, in fact a much more human femur—modified probably in the chimpanzee direction—but built for strength rather than agility. If the branch-point of the Gibbon be definitely later than this Prot-simio-human, then its evolution will be found to be from the robust to the less robust. The Eppelsheimer femur, more robust than those of recent gibbons, is a simplification of a still more robust, and a more bowed femur.

We admit that this unorthodox view is tentative and will be unsympathetic as reinstating a more troglodyte ancestry for man[1]. It accounts, however, to some extent for the suggestive "primitiveness" of several human characters. The crucial test will come not with the discovery of fossil ancestors of the Gibbon, but with that of fossil ancestors of the troglodytes; these, on our hypothesis, should be more human than we have hitherto supposed—a lighter phase of the Neanderthal femur—which would in some respects make it more recent man-like, but also would probably draw it towards the Chimpanzee. In one respect, that of pithecoid index, it might turn out to be more orangoid than chimpanzee-like. Until the discovery of fossil troglodyte members of the simio-human group has been made we can but see how far our views are in accord with a wider if less intensive[2] study of the femora of the whole range of primates. This we propose to undertake on the basis of the measurements published in this section in an Appendix to be issued as Part III of the text of this monograph.

It will of course be objected, and the criticism is justified, that all our conclusions have been based on a study of a single bone. But then the chief aim of this monograph has been and will continue to be the discovery of how much can be ascertained from the intensive study of single bones. As far as man is concerned the measurements have been taken, tabled and reduced for a variety of other long bones, and it is solely the very limited powers of computation, analysis, and publication which are and have been at the service of the Biometric Laboratory that have delayed through long years even the appearance of Parts I and II of this work. Only with the publication of the sections on the Humerus or the Tibia will it be possible for the first time to ascertain how far conclusions based on a single bone may be safely extended to the whole organism. At any rate up to the present we believe that attention possibly has been too much concentrated for evolutionary purposes on the primate cranium, or even on the mandible alone. It is from this standpoint desirable to discover the extent to which other bones of the skeleton confirm or contradict the conclusions drawn from the skull or the teeth.

[1] We fear that what Professor Wood-Jones terms the "stain" on British science will not be washed away by any Tarsian fluid hypothesis. Our Prot-simio-human was troglodytic, an ape if a more refined ape than the gorilla!

[2] Less intensive in that for Recent Man we have measured many hundred femora, while in the case of the other primates we must perforce content ourselves with the few femora we have been able to measure of each species.

APPENDIX I

Correlation of the Femoral Characters in Man

So few exact determinations have been made of the correlation between femoral characters that we propose to cite in this appendix certain comparative values.

(*a*) Our first series is due to Tamagnini and de Campos whose memoir on the Portuguese femur[1] appeared after our chapter on correlation was printed off and accordingly could not then we regret to say be used for comparative purposes. It is the only memoir we are acquainted with which applies modern statistical methods to the study of the femur, and the authors are to be congratulated on thus breaking away from the old anatomical school of anthropologists. Where possible we give our own values for comparison. Except in the case of Bicondylar Width with Diameter of Head, where the numbers are ♂ 264, ♀ 250, the Portuguese authors appear to have worked with 134 male and 126 female femora. In the case of correlation of Collar

Character Pair	Portuguese		17th century Londoners	
	♂	♀	♂	♀
Excess of Maximum over Oblique Length and Obliquity	0·70 ± 0·03	0·83 ± 0·02	—	—
Excess of Maximum over Oblique Length and Collar Angle	0·08 ± 0·06	−0·04 ± 0·06	—	—
Excess of Maximum over Oblique Length and Bust Length	−0·06 ± 0·06	?	—	—
Oblique Length and Diameter of Head ...	0·09 ± 0·06	0·07 ± 0·06	·561 ± ·033*	·408 ± ·046*
„ „ „ Pilastric Transverse ...	0·03 ± 0·06	0·06 ± 0·06	·331 ± ·040‡	·115 ± ·050‡
„ „ „ Pilastric Ant. Post. Diam.	0·07 ± 0·06	0·10 ± 0·06	·331 ± ·040‡	·353 ± ·044‡
„ „ „ Distal Articulation Width	0·08 ± 0·06	0·05 ± 0·06	·556 ± ·037*†	·434 ± ·053*†
„ „ „ Index of Platymery ...	0·02 ± 0·06	0·01 ± 0·06	−·007 ± ·045*	+·121 ± ·054*
„ „ „ Length of Bust	0·11 ± 0·06	0·08 ± 0·06	·262 ± ·044	·058 ± ·054
„ „ „ Collar Angle	0·02	? ♂ + ♀	·256 ± ·043	·211 ± ·050
„ „ „ Obliquity	−0·01 ± 0·06	−0·02 ± 0·06	−·092 ± ·045	−·047 ± ·052
Collar Angle and Obliquity	−0·06 ± 0·06	−0·13 ± 0·06	−·244 ± ·044	−·194 ± ·052
Length of Bust and Obliquity	−0·01 ± 0·06	0·04 ± 0·06	—	—
„ „ „ „ Collar Angle	0·03 ± 0·06	0·08 ± 0·06	−·222 ± ·043	−·257 ± ·048
„ „ „ „ Distal Articulation Width	0·43 ± 0·05	0·52 ± 0·04	·356 ± ·047	·321 ± ·050
„ „ „ „ Diameter of Head ...	0·48 ± 0·04	0·51 ± 0·04	·354 ± ·042	·284 ± ·050
Distal Articulation Width and Diameter of Head	0·63 ± 0·03	0·63 ± 0·03	·760 ± ·023	·619 ± ·043
Angle of Torsion and Platymeric Index ...	0·05 ± 0·06	−0·02 ± 0·06	−·082 ± ·047	−·006 ± ·054
Pilastric Ant. Post. and Transverse Diameter...	0·45 ± 0·05	0·45 ± 0·05	·285 ± ·040	·271 ± ·045

* Correlations for maximum instead of oblique length.

† Correlations for bicondylar width not distal articulation width.

‡ Correlations with shaft length and not oblique length.

[1] Bibl. 118.

Angle and Length of Femur the value only is given without statement as to sex or number. Their "Length of Neck" finds its nearest equivalent in our Capito-collar Axis or Bust Length but is otherwise determined. We regret to say that we cannot accept the values Tamagnini and de Campos give for the correlations of size of femur with its transverse dimensions. We obtain much more substantial values, and these seem in accordance with the mere appreciative experience that *on the whole* larger or longer femora have greater transverse sections. We are also disinclined, especially in view of our own results, to accept the view that there is no sensible *negative* relation between collar angle and length of bust. Is it possible that in these cases some error has crept into the calculations based upon what was probably a novel mathematical procedure to the computers ? We cannot test these results ourselves as the individual measurements are not provided by the authors. We cannot blame the authors for the non-publication of the correlation-tables ; that may be in their case as in ours one of the economic effects of the war, but the complete absence of the raw data although it receives some sanction from frequent French practice is a grave disadvantage when it is needful to check or extend conclusions.

(*b*) Our second series of correlations has been deduced by us with the aid of a somewhat novel procedure from data given by Antony and Rivet in their memoir[1] often cited in our pages upon the prehistoric Indian femora of Paltacalo. These authors deal with a small series of about 69 ♂ and 52 ♀ femora. They divide their material up into three approximately equal groups according to one character[2] and find for each of these groups the mean value of the second. They then judge from the relative value of these three means whether there is any association, occasionally asserting it to exist when the three means do not run all in one sense. There are three obvious criticisms : (*a*) the authors' numbers—which may for certain characters not exceed 32—are very sparse for such a rough procedure, (*b*) the method does not provide, even if it were justified by size of categories, any quantitative measure of association, and (*c*) if any three numbers be taken *at random*, say m_1, m_2, m_3 in ascending order to represent the means of the three categories, then we can make six arrangements of them, namely :

(1)	(2)	(3)	(4)	(5)	(6)
m_1	m_3	m_1	$\left\{\begin{matrix} m_2 \\ m_1 \end{matrix}\right.$	$\left\{\begin{matrix} m_2 \\ m_3 \end{matrix}\right.$	m_3
m_2	m_2	$\left\{\begin{matrix} m_3 \\ m_2 \end{matrix}\right.$	m_3	m_1	$\left\{\begin{matrix} m_1 \\ m_2 \end{matrix}\right.$
m_3	m_1				

The first two (1) and (2) give "clearly" positive and negative correlation. The third and fourth (3) and (4) positive correlation, and (5) and (6) negative correlation, if the examiner actually puts in or visualises the brackets.

Omitting the associations with bowing Antony and Rivet give 104 tables of this kind, of which 53 show positive, 50 negative and one zero correlation[3]. They have no quantitative standard of which are significant and which insignificant. Some they say mean nothing and others they accept as important, although very often the two sexes

[1] Bibl. 98 *bis*.

[2] *i.e.* into high, medium and low value classes.

[3] The proportions are of course strikingly close to those that would be obtained by random selection in the case of uncorrelated material.

run in opposite directions[1]. Now the probable error of a coefficient of correlation based upon the numbers used by the present authors is of the order ·08 to ·10. Hence the material they provide is inadequate to determine whether there is correlation or not, unless the correlation coefficient exceeds at least ·20. Can we then obtain approximate values for the correlation? Let $\tilde{y}_1$ and $\tilde{y}_3$ be the means of the high and low groups corresponding to the mean abscissae $\tilde{x}_1$ and $\tilde{x}_3$ of those groups. Then, assuming the regression linear, $(\tilde{y}_1 - \tilde{y}_3)/(\tilde{x}_1 - \tilde{x}_3) =$ the regression coefficient, $= R$ say. It follows therefore that the correlation will be

$$r = R\sigma_x/\sigma_y .$$

Hence if we can find σ_x and σ_y since R is known we have an approximate value of r. Unfortunately the material for the determination of σ_x and σ_y is often very slender; the frequency distributions of the characters are not always given, and when provided are often arranged in sadly few groups. However we have ventured on 42 correlation coefficients which are given below, our own being added when known.

Character Pair	Paltacalo Indians		17th century Londoners	
	♂	♀	♂	♀
Collar Angle and Oblique Length ...	+ ·150*	− ·140*	+ ·256 ± ·043	+ ·211 ± ·050
„ „ „ Platymeric Index ...	+ ·082*	+ ·144*	+ ·366 ± ·038	+ ·357 ± ·044
„ „ „ Pilastric Index ...	+ ·016*	− ·164*	—	—
„ „ „ Torsional Angle ...	+ ·031*	+ ·107*	—	—
„ „ „ Ellipticity of Neck ...	+ ·015*	+ ·260	+ ·057 ± ·044	+ ·284 ± ·045
„ „ „ Length of Bust	− ·050*	− ·392	− ·222 ± ·043	− ·257 ± ·048
Platymeric Index and Oblique Length ...	+ ·332	− ·469	− ·007 ± ·045	+ ·121 ± ·054
„ „ „ Pilastric Index ...	+ ·518	+ ·359	+ ·503 ± ·032	+ ·396 ± ·042
„ „ „ Torsional Angle ...	+ ·098*	− ·413	− ·082 ± ·047	− ·006 ± ·054
„ „ „ Ellipticity of Neck	− ·007*	− ·008*	+ ·010 ± ·044	+ ·154 ± ·051
„ „ „ Length of Bust ...	+ ·054*	− ·011*	—	—
Pilastric Index and Oblique Length ...	− ·021*	+ ·261	+ ·153 ± ·044	+ ·202 ± ·049
„ „ „ Torsional Angle ...	+ ·358	+ ·297	− ·096 ± ·046	+ ·055 ± ·054
„ „ „ Ellipticity of Neck ...	+ ·126*	− ·191*	—	—
„ „ „ Length of Bust ...	− ·013*	+ ·256	—	—
Torsional Angle and Oblique Length ...	− ·130*	+ ·471	− ·047 ± ·047	+ ·100 ± ·053
„ „ „ Ellipticity of Neck ...	+ ·072*	− ·066*	—	—
„ „ „ Length of Bust ...	+ ·013*	+ ·112*	− ·200 ± ·045	− ·247 ± ·052
Ellipticity of Neck and Oblique Length ...	+ ·037*	− ·174*	—	—
„ „ „ „ Length of Bust ...	+ ·079*	− ·117*	—	—
Length of Neck and Oblique Length ...	+ ·246	+ ·378	+ ·262 ± ·044	+ ·058 ± ·054

In all the cases marked with an asterisk the data are insufficient to determine whether there is or is not correlation let alone its sign or magnitude. In the bulk of cases therefore Antony and Rivet should not have expressed any other opinion than "data inadequate to determine whether or not association exists." In cases where comparison is possible we may note good accordance in Collar Angle with Ellipticity of Neck, the emphasis of female over male being repeated. In Collar Angle and Length of Bust the negative sign is confirmed. We cannot substantiate the high negative value

[1] The sex proportions of the correlations are ♂: 33 +, 19 − and no zero; ♀: 20 +, 31 − and 1 zero. Thus the females have more negative and the males more positive associations.

of the correlation between Platymeric Index and Oblique Length for female femora and think that Antony and Rivet's 13 femora of the low length class possibly contained certain anomalous bones of accentuated platymeric character. The evil of such small numbers is that one or two anomalous bones may upset the complete system of the series. This remark applies equally to these authors' result for the correlation of platymery and torsion in the case of the female bones. All their torsional results are indeed difficult to accept under the circumstances. It is not only that the material is also inadequate, but the method of presentation is inadequate having regard to modern statistical requirements. We have introduced this table, so that we may in the first place not be charged with overlooking other people's work, but in the second place more especially because we want it definitely recognised that it will only be possible to distinguish racial and sexual differences in correlation where series are available which amount to several hundred at least for each sex. Until we know what is the order of racial and sexual variations in correlation it is simply impossible to assert from small series that certain associations hold in femoral characters; to affirm such relations is merely throwing back anthropometry, in particular osteology, into the slough in which it floundered during the last century.

APPENDIX II

Femora of Fossil Lemuroids from Middle Eocene, Bridger Formation, U.S.A.

I owe to the kindness of the authorities of the American Museum of Natural History casts of the long bones of the recently found fossil lemuroids. The two of which femora have survived have been named *Notharctus osborni* and *Notharctus tenebrosus* (Leidy). The discovery of these fossil lemuroids taken in conjunction with the earlier finding of European fossil lemuroids[1] completes Wallace's argument that the hypothesis of Lemuria—a continent once linking up Borneo with Madagascar—is idle, for the Lemuroids would ultimately be found to have been spread not only through the old but the new world. The femora are in fairly good condition, although obviously much labour and care have been spent in piecing them together. Thus the measurements given in the accompanying table are to some extent open to question, and not too much stress must be laid on such characters as the torsion and bowing. A full discussion on the relationships of these lemuroids is at present preparing for press, and in the able hands of Dr Gregory. Here we content ourselves with a few remarks suggested by a comparison of the present system of femoral characters with those recorded in the last chapter of our monograph.

[1] H. Filhol: "Mammifères fossiles d'Europe et d'Amérique," *Annales des sciences géologiques*, T. 14, pp. 1—51. Paris, 1883.

TABLE I. *Femora of Fossil Lemuroids from Middle Eocene, U.S.A.*

	Characters (from casts)	*Notharctus osborni* (R.)	*Notharctus tenebrosus*, Leidy (R.)
Major Lengths	Maximum Length	123·3	139·5
	Trochanteric Length	121·5	138·6
	Maximum Trochanteric Length	121·9	138·9
	Oblique Length	123·2	139·4
	Trochanteric Oblique Length	121·2	138·5
	Capito-trochlear Length	121·2	137·8
	Diaphysial Length	103·2	121·0
	Length of Shaft	114·7	127·8
Bust	Vert. Diameter of Head	10·2	12·8
	Horiz. Diameter of Head	10·4	12·7
	Minimum Horiz. Diameter of Neck	6·4	7·8
	Minimum Vert. Diameter of Neck	8·6	10·0
	Capito-collar Length	13·4	20·2
	Length of Neck	8·3	13·8
Shaft	Proximal Breadth	20·9	24·0
	Platymeric Ant. Post. Diameter	7·7	7·6
	Platymeric Transverse Diameter	7·8	9·5
	Pilastric Ant. Post. Diameter	8·6	8·0
	Pilastric Transverse Diameter	8·7	9·1
	Popliteal Length	?	?
	Popliteal Width	8·0	10·6
	Popliteal Direct Ant. Post. Diam.	7·2	7·8
	Popliteal Oblique Ant. Post. Diam.	7·6	8·0
	Diaphysial Chord	70·9	83·5
	Diaphysial Subtense	0	2·0
	Prox. Segment Diaphysial Chord	?	56·4
Condyles	Bicondylar Width	16·7	19·7
	Max. Length Ext. Condyle	18·2	20·1
	Max. Length Int. Condyle	16·0	18·3
	Oblique Length Ext. Condyle	17·0	19·6
	Oblique Length Int. Condyle	15·6	18·2
	Ext. Condyle Horiz. Band-radius	5·1	6·3 ?
	Ext. Condyle Vert. Band-radius	5·1	6·4 ?
	Height of Patellar Surface	12·0	11·9
	Breadth of Distal Articulation	14·6	18·0
Angles	Midtrochlear Angle	4°·8	7°·4
	Angle at Centre of Head	46°·0	56°·4
	Collar Angle	129°·0	116°·2
	Torsion of Shaft	19°·0	29°·3
	Torsional Angle	29°·9	22°·8
	Retorsional Angle	−10°·9	+6°·5
	Obliquity	2°·0	1°·0
	Pseudo-Obliquity	2°·3	2°·15

	Indices (from casts)	*Notharctus osborni* (R.)	*Notharctus tenebrosus*, Leidy (R.)
General Indices	Oblique Direct Lengths Index	99·92	99·93
	Oblique Direct Troch. Lengths Index	99·75	99·93
	Proximal Breadth Ratio	17·20	17·32
	Distal Breadth Ratio	13·74	14·21
	Pithecoid Index	98·38	99·35
	Robusticity of Femur	14·04	12·27
Bust Indices	Robusticity of Head	16·72	18·29
	Ellipticity of Head	98·07	100·79
	Ellipticity of Neck	74·42	78·00
	Secondary Index of Neck	61·54	61·42
	Lemotic Index	6·74	9·90
	Head Bust Ratio	76·12	63·37
	Primary Bust Ratio	10·87	14·48
	Secondary Bust Ratio	10·88	14·49
	Bust Shaft Index	11·68	15·81
	Capital Ratio	8·27	9·18
	Capito-bicondylar Ratio	61·08	64·97
	Epiphysial Ratio	80·24	102·53
Shaft Indices	Platymeric Index	98·72	80·00
	Pilastric Index	98·85	87·91
	Popliteal Index	90·00	73·58
	Index of Popliteal Skewness	94·74	97·50
	Popliteal Pyramidal Index	?	?
	Soffit Index	47·90	53·81
	Index of Gracility (Upper)	111·54	95·79
	Index of Gracility (Lower)	108·75	85·85
	Index of Transverse Slenderness	7·6	8·6
	Index of Sagittal Slenderness	7·5	6·3
	Index of Proximal Taper	89·53	95·00
	Index of Distal Taper	83·72	97·50
	Popliteal Shaft Index	?	?
	Primary Index of Bowing	0	2·40
	Secondary Index of Bowing	?	67·54
Condylar Indices	Condylar Index	108·98	102·03
	Condylar Lengths Index	113·75	109·84
	Bicondylar Ratio	13·54	14·12
	Band-radial Index	100·00	98·44 ?
	Condylar Trochanteric Index	14·98	14·42
	Distal Articulation Ratio	11·84	12·90
	Distal Articulation Index	87·43	91·37
	Rotular Ratio	9·73	8·53
	Rotular Index	82·19	66·11
	Diaphysial Rotular Ratio	11·63	9·83

REMARKS. *Notharctus osborni*, Granger and Gregory (A. M. of N. H. 11474), Bridger formation, Bridger Basin (Horizon B), Wyoming, U.S.A. Head, with very slight evidence of *fovea*, slightly above great trochanter. Lateral protrusion with ridge form of 3rd trochanter. Very little anterior flattening, 2nd and 3rd trochanters roughly balance from posterior aspect, where the flattening is subtrochanteric. No pilaster. Marked posterior fossa but on mesial border of posterior face. Ill-defined popliteal surface without apex, flat to concave. No sensible bowing, but difficult to determine, of slight value as bone has been pieced together from fragments. Head fairly well defined but with extension on to top and posterior face of neck, no marked cut-away. Top of neck flat and broad. Patellar surface *m.r.*, of moderate length and with short tongue. Axis of shaft cuts neck at basis of head. Plane perpendicular to standard plane touching mesial epicondyle and top of 2nd trochanter only just grazes head. *Notharctus tenebrosus*, Leidy (A. M. of N. H. 1727), Bridger

formation, Bridger Basin (Horizon B), Wyoming, U.S.A. Head with no sign of *fovea* and with great trochanter very nearly same level. Lateral protrusion and 3rd trochanter more massive than in *N. osborni.* Very little anterior flattening, posterior is below both 2nd and 3rd trochanters. No pilaster, no identifiable posterior fossa. Popliteal surface, flat, without apex and ill-defined. Slight positive bowing, but in present state not easy to measure. Two rather well-marked ridges appear to connect popliteal area with lateral upper border of mesial condyle and mesial upper border of lateral condyle. There are *cavities* to mesial and lateral sides of these ridges, where the two heads of *gastrocnemius* would usually be inserted. Head rather poorly defined, but probably damaged; extension on to top and posterior face of neck. ? a posterior cut-away or damage. Top of neck broad. Patellar surface *b.r.* to *m.r.*, moderate to short in length and but small signs of tongue. Axis of shaft passes through tip of great trochanter. Plane perpendicular to standard plane and touching mesial epicondyle and tip of 2nd trochanter intersects neck and base of head.

If we neglect absolute size and confine our attention to indices then a comparison of the mean values in Table III of the last chapter certainly suggests that *Notharctus osborni* corresponds most closely to the true Lemurs. In a number of respects *Notharctus tenebrosus* has a femur closer to that of *Chiromys* than to that of the true Lemurs. But both femora combine features which no longer appear common to recent lemuroids. Thus a very noteworthy feature of *Notharctus osborni* is that the mesial epicondyle, the tip of the lesser trochanter and the head can practically all be touched by one and the same plane drawn perpendicular to the standard vertical plane. Now this is a characteristic approximated to in the *Lorisinae* (*Potto, Loris gracilis* and *Nycticebus javanicus*); it is further approached in *Tarsius,* and occasionally in the *Galaginae.* We have no approach to it in our experience of the *Lemurinae* or *Indrisinae.* It is not in the least characteristic of *Notharctus tenebrosus.* In this respect *Notharctus osborni* resembles rather what we have termed the Tarsiidean than the Lemurine group of Lemuroids. It suggests therefore a transition form from the earlier lemuroids to the true lemurs. On the other hand in a rough way *Notharctus tenebrosus* links up the Aye-Aye and the true lemurs. Taking the above referred to relation of linearity in epicondyle, tip of second trochanter and head as a very marked differential of lemuroid genera, we are by no means certain that it would not be advisable to place the two fossils in separate genera. On the other hand the insignificance of the third trochanter in the *Lorisinae* is a feature which is not shared by *Notharctus osborni.* The third trochanter of the latter is a ridge form, which is lemurine, while that of *Notharctus tenebrosus* approaches more the nipple shape of the third trochanter of the Aye-Aye. Nor are these combinatory results improbable, if we consider that we are passing to forms closely allied to the ancestral types of recent lemuroids. A suggestive fact is that we have not been able to trace any approach to linearity of mesial epicondyle, second trochanter and head in the femora of any Old World monkeys, nor in the European fossil lemur *Adapis.* But approaches to this condition are certainly to be found in the *Cebidae,* and most notably in their more primitive forms such as the marmoset. If this be correct the American Eocene fossil lemuroid is closer to certain of the *Cebidae,* than the European Eocene lemuroid. The point is, perhaps, worthy of fuller study as the character is a marked one, and the criterion easily applied. If the tangent be drawn (on the projection of the femur on the standard vertical plane) from mesial epicondyle m, to touch the head in h, and the distance from the tip t of the trochanter minor to this tangent be tn, then the convenient index $100\ tn/mh$ may be formed and can for convenience be called the *Aspalacoid Index.* Table II on the following page gives the value of the Aspalacoid Index for the Primates

TABLE II. *The Aspalacoid Index for the Primates with Comparatives.*

Monotremes ...	*Ornithorhynchus*	−20·20		PRIMATES (*cont.*)			
	Echidna	4·15		Recent Lemuroids	*Indrisinae* (8)	4·35	4·80
Marsupials ...	*Trichosurus vulpecula* (2)	3·16			*Lemurinae* (20)	5·25	
	Phascolomys ursinus	6·48		Cebidae ...	*Hapalinae* (18)	2·44	
	Macropus frenata	7·59			*Nyctipithecinae* (8)	4·48	
Chiroptera[1] ...	*Pteropus medius* (Flying Fox) ...	−4·54			*Brachyurus* (2)	5·54	Mean 6·28
	Pteropus sp. (Mollaques)	−6·18			*Pithecia* (2)	5·92	
	Pteropus conspicillatus (2)... ...	−7·02			*Ateles* (4)	6·71	
Edentates ...	*Dasypus sexcinctus*	0·00			*Cebus* (8)	6·71	
	Choloepus didactylus (3)	2·12			*Mycetes* (2)	8·04	
	Tatusia peba	5·59			*Lagothrix* (2)	10·39	
	Tamandua tetradactyla	10·98		Simiadae ...	*Macacus* (18)	5·04	Mean 5·78
Rodents ...	*Sciurus vulgaris* (2)	−0·00			*Cercocebus* (4)	5·48	
	Castor fiber	1·12			*Cercopithecus* (8)	5·62	
	Hesperomys	1·27			*Semnopithecus* (10)	6·03	
	Lepus cuniculus	3·66			*Cynocephalus* (8)	6·72	
	Fiber zibethicus	6·49		Anthropoidea, Hylobatinae	*Dryopithecus rhenanus*	6·39	
	Dasyprocta	10·00			Gibbon (3)	6·06	
	Castor canadensis (2)	10·10		Simiinae ...	Orang-utan (5)	9·63	Mean 11·68
Carnivores ...	*Felis domestica*	6·78			Chimpanzee (5)	10·94	
	Canis familiaris (Pekinese Spaniel)	7·10			Gorilla (11)	14·47	
	Lutra vulgaris (Common Otter) ...	12·50			*Pithecanthropus erectus*	10·31	
	Leo africanus (2)	12·73		Primogenial Man	Type A. La Ferrassie I	13·64	Mean 12·48
	Latax lutris (Sea Otter)	17·47			La Chapelle-aux-Saints ...	13·01 ?	
Ungulates ...	*Equus caballus*	3·78			*H. mousteriensis* (*Hauseri*)	12·84	
	Ovis domesticus	6·62			Spy	12·07	
Insectivores ...	*Talpa europaea*	0·00	0·59		Neanderthal	10·84	
	Hylomys suillus dorsalis	0·40			Galley Hill	9·93 ?	
	Tupaia chrysura	0·00			Cromagnon Type (2) ...	10·58	
	Tupaia picta (2)	0·98			Grimaldi Negroid Type (2)	10·48	
	Tupaia minor (2)	1·57		Recent Man ...	Andaman (1)	4·99	
PRIMATES					Bushmen (2)	8·22	
Fossil Lemuroids	*Notharctus osborni*	0·00			Modern Europeans (15)	8·65	
	Adapis parisiensis	3·40			Fuegian (1)	10·90	
	Notharctus tenebrosus (Leidy) ...	4·35			Australians (2)	11·85	
Recent Lemuroids	*Tarsiidae* (3)	1·47	1·89				
	Galaginae (6)	1·85					
	Chiromyrdae (2)	2·04					
	Lorisinae (6)	2·20					

[1] We have examined a number of other species of Chiroptera and find the Aspalacoid Index always negative.

and a few comparatives which were available in the Biometric Laboratory at the time it was drawn up. This index measures the degree to which this mole-like femoral character appears in other species.

Examining the table we see that in the Tupaids the index is extremely low, and that this is also the case of the Tarsiidean group of the Lemuroids. The *Simiadae* and *Cebidae* advance sensibly, even on the true Lemurs, but the Old World monkeys have nothing like the range of values of the femora of the New World monkeys, the marmosets and *Lagothrix* being of the latter the outlying forms. The marmosets (2·44) approach nearest to the Tarsiidean group of the Lemuroids, and are for this index closer than any of the *Simiadae* to the fossil lemurs. The low values of the Aspalacoid Index in the fossil lemurs carry us distinctly a stage towards the Tarsiidean group and ultimately towards the Tupaids. Turning to the *Anthropoidea,* we note that the Recent Gibbon is not very widely differentiated from *Dryopithecus rhenanus* and both are fairly close to *Ateles,* and widely differentiated from the Greater Anthropoids. *Pithecanthropus erectus* is distinctly human[1] or if we please troglodyte, but not hylobatic. The *Simiinae* show a big advance on the *Simiadae* and this advance is continued in Primogenial man of the Neanderthal Type. With the Cromagnon Type comes a fall,—the Grimaldi Negroid Type having the same index as Cromagnon,—and this fall is continued in Recent Man of the European Type. Thus this new index—suggested by the striking characteristic which differentiates *Notharctus osborni* from *Notharctus tenebrosus,* Leidy—confirms much that we have already learnt from our detailed analysis of other femoral characters, especially the reversion of Recent Man from a greater to a less troglodyte character, *i.e.* he stands on the other side of the Greater Anthropoids to Neanderthal Man, and so somewhat closer to the Lesser Apes than Primogenial Man.

APPENDIX III

The sesamoid bones of the Knee-joint of the Primates

One or more of at least seven sesamoid bones may be found associated with the knee-joint of the Primates. The *fabellae* occurring as anomalies in the *gastrocnemius* tendon of man are invariable in many genera of the Primates, and are recorded as "sesamoid bones" in the "Remarks" to Tables of Femoral measurements of the Primates in Part II of the *Atlas* to this monograph. But our investigations into the sesamoids of the knee-joint of the Primates have developed to such an extent, that we have thought it necessary to suppress this appendix and to publish an independent memoir on the subject.

[1] The range of Europeans is about 6 to 11.

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I. INDEX TO AUTHORITIES QUOTED IN THE TEXT

ABEL, on pedigree of primates 480, 481. ALBRECHT, on third trochanter 66, 69, 74. AMEGHINO, *Tetraprothomo* of 404, 410. ANTONY, data of 238, 240, 243, 246, 253, 358, 359, 370, 371, 375, 377, 390, 393; on bowing of femur 33, 276, 277, 279—286, 460; measurements on apes of 387, 450; material for femoral correlation from 506—508.

BAILEY, data of 238. BARKOW, on process on femur 64, 69, 84, 85. BAXTER, data of 236. BENINGTON, CREWDSON, measurements of 2. BERTAUX, on bowing of femur 33; data of 76, 77, 367, 370, 375, 378; on facet on neck of femur 90; index of neck 374; measurements on apes of 387; reconstruction of Krause's condylar contours 26. BERTRAND, on influence of age on pilastric index 269. BISCHOFF, data of 237. BONSDORFF, data of 236. BOULE, on form of shaft, 455, 456, 458; on man of La Chapelle-aux-Saints 451, 452, 453; on relative size of condyles 458. BRAMLEY MOORE, measurements of 2. BRIGHAM, data of 237. BROCA, on pilastric index 252; on torsion 25, 26; on tropometer 25. BROEK, on orientation of pelvis 138, 139, figs. i—iv. BUMÜLLER, on band-radial index 19, 395—398, 443; on bowing of femur 34, 283; on condyles of femur 39, 388, 395, 400—403, 410, 411, 458; on correlation of pilastric and platymeric indices 261, 262; data of 16, 235, 237, 244, 253, 254, 299, 358, 367, 371, 375, 390, 393, 405, 407, 412, 417; on diaphysial length 228, 229; on influence of age on shaft indices 269; on platymeric range 8; on popliteal curvature 288, 291; on shaft indices 298, 303, 309; on Trinil femur 17, 259, 310, 340, 380, 384, 411.

CHARLES, on facet on condyle of femur 104—106. CHARPY, data of 109, 110, 111, 367, 371; on female pelvis 379. COSTA, on anomalies of femur in anthropoids and man 66, 70—73, 75, 104; data of 76, 77. CRUVEILHIER, on third trochanter in man 63, 64. CUVIER, on third trochanter 63.

DALGLIESH, assistance of 4. DERRY, assistance of 3. DOLLO, on third trochanter of Dinosauria 69. DUBOIS, data of 370; on *Dryopithecus rhenanus* 340; on Trinil femur 14, 17, 287, 340, 451, 481, 487, 503. DUPONT, on third trochanter 64. DWIGHT, on *Crista hypotrochanterica* 69; data of 77; on sexing of femora 41—47, 49, 51, 61.

ECKER, data of 238. EVANGELI-TRAMOND, on association of *fossa hypotrochanterica* with platymery 79; on bowing of femur 33; on bust ratios 363; data of 76, 110, 167, 364, 367, 370; on facet on neck of femur 90, 91, 112; on neck of femur 363, 374; on sexual character of anomalies 74.

FICK, on facet on neck of femur 90, 91, 93; on pelvis in pregnancy 140. FLOWER, on third trochanter 65. FOOTE, on histology of femur 270, 271. FRAIPONT, data of 390, 452. FRITSCH, data of 236, 238. FÜRST, C. M., data of 77; on third trochanter 70, 72. FÜRST, L., on pelvic inclination 137.

GALTON, data of 236. GARSON, on asymmetry in length of limbs 128, 130. GAUDRY, on ancestry of man 481. GOULD, data of 236. GREGORY, on fossil lemuroids 508. GRUBER, on gastrocnemic tubercles 85—87; on Wilbrand's process 85, 86. GULDBERG, on bowing of femur 34, 276, 278, 279.

HAECKEL, his pedigree for primates 480, 487, 503. HAMY, torsion angle of 27. HENKE, on facet on neck of femur 90. HENZELT, on supracondyloidal area 86, 87. HEPBURN, data from 235—238, 243, 247, 250, 251, 253, 254, 310, 358, 359, 383, 390, 391, 393; measurements on British femora 122—127, 167—170; measurements on gorilla 450; on platymeric index 7; on popliteal region 9, 12—16, 298, 307, 308; on soffit index 36, 37. HIRSCH, on association of collar angle with other characters 372. HOLDEN, on third trochanter 64. HOLTBY, data of 247, 251. HOUZÉ, on *fossa hypotrochanterica* 65—68; on third trochanter 65—68, 70—73, 74, 76. HRDLIČKA, data from 42, 45, 47, 404, 405, 407, 410, 412. HULTKRANTZ, on condylar lengths 401; on condylar ratios 414; data from 233, 234, 243, 246, 251, 254, 346, 347, 358, 370, 375, 390, 391, 393, 405, 412, 417; on torsion angle 27. HUMBOLDT, data from 236. HUMPHRY, on collar angle in young and adult bones 110, 111, 199; on third trochanter 64. HUNT, data of 236.

JOB, on axis of condyles 26; trepsimeter of 25.

KEITH, assistance of 84. KLAATSCH, on condylar lengths and indices 17, 39, 401, 402, 414; on relative size of condyles 458; on correlation of pilastric and platymeric indices 262; data of 234, 241, 253, 358, 388, 404, 405, 407, 412, 417; indices of 231, 232, 233; on origin of man 409, 464; on *Pithecanthropus erectus* 17, 402; on popliteal measurements 9, 10, 13; on primogenial man 452, 455, 456; on proximal breadth 345, 346; on soffit index 37; on trochanteric length 4, 227. KOGANEI, on coaxial point 363; data of 234, 235, 238, 251, 253, 383, 390, 393; on platymeric index 128; on trochanteric length 4; variability of his measurements on the Aino 166—170, 174. KOLLMANN, data of 238. KRAUSE, condylar contours of 26. KROUTOWSKI, on shaft indices 260. KUHFF, on bowing of femur 33, 34; data of 247, 251, 370, 371, 375. KUKNOW, on pelvis in pregnancy 140.

LANGER, data of 367, 371. LEE, assistance of 2. LEHMANN-NITSCHE, on angles associated with neck of femur 23, 127; on classification of platymery 8, 9; on condylar lengths 401; data of 234, 235, 236, 240, 246, 251, 254, 359, 371, 375, 390, 393; on measurement of bowing 33, 34; on torsional angle 27; on trochanteric length 4. LISTER, data from 236. LOHEST, data from 390, 393, 452. LUDWIG, on sexual character of third trochanter 74. LUSTIG, data of 367, 371.

Macalister, assistance of 8, 78. Macdonell, on seventeenth century English crania 1, 2. Manouvrier, on bowing of femur 34, 281, 283; on correlation of pilastric and platymeric indices 260, 261, 262; data of 111, 237, 240, 243, 244, 246, 358, 359, 370, 371, 377; on Neolithic man 476; on *Pithecanthropus erectus* 13; on platymeric index 7—9, 252, 260, 261; on popliteal region of femur 9, 12—14, 16, 252, 253, 288. Marche, data of 238. Marshall, data of 236. Martin, on condylar lengths 401; data from 234, 235, 238, 240, 246, 254, 367, 370, 371, 390, 391, 393. Mathews, data from 250, 254. Matiegka, on asymmetry in length of femur 128—130. Meyer, on pelvic inclination 137, 138. Mikulicz, anatomical axis of femur of 230, 231; data of 240, 244, 367, 371. Miller, measurements of 2. Mollison, on bowing of femur 280; data of 104, 234, 240, 243, 246, 251, 253, 358, 359, 368, 371, 383, 390, 393; on trochanteric length 4. Montano, data of 238. Montegazza, data of 238. Moveno, data from 236.

Naegele, on orientation of the pelvis in man 137, 138. Newton, on Galley Hill femur 451.

Owen, on third trochanter 65; on Tilbury femur 451.

Parsons, on asymmetry in length of femur 130; on axis of condyles of femur 25, 26; on axis of neck 21; on bowing of femur 34, 35; bust ratios from 363, 364; on capito-collar length 360; on collar angle 21, 125; comparison of his measurements on Rothwell femora with those on the London series 124—127, 167, 168; correlations calculated from measurements of 197, 198, 200, 215—217; data from 235, 237, 240, 244, 254, 358, 371, 378, 388, 390; on distal articulation width 125, 126; on maximum and oblique femoral lengths 227; on neck length 22; on obliquity of shaft 30, 125; on pilastric measurements 247; on platymeric index 125, 126; on Poirier's facet 93; on robusticity of femur 247, 248; on sexing of femora 43, 44, 49, 50, 58, 59, 61; on torsional angle 25, 27, 28, 125. Paul-Boncour, on correlation of pilastric and platymeric indices 262; on sound and sick limbs in infantile hemiplegia 109, 110, 111. Pearson, on reconstruction of stature from femur 5, 227. Petrie, material from 1, 41. Pilgrim, on ancestry of man 503. Pitt-Rivers, data of 236. Pohlig, on ancestry of man 481; on naming of Eppelsheimer femur 340. Poirier, on facet on neck of femur 90—104. Prochownick, data from 232, 233, 234, 346, 347, 367, 370, 390, 391, 393. Pruner Bey, on third trochanter 64. Psengrüber, data from 237.

Radford, measurements of 2. Rahon, data from 236, 237. Ranke, data from 236—238. Regnault, on effect of use on bones 111, 112; on Poirier's facet 111, 112. Rivet, on bowing of femur 33, 276, 277, 279—286, 460; data from 238, 240, 241, 243, 246, 253, 358, 370, 375, 387, 390, 393; on material for femoral correlations from 506—508; measurements on apes of 450. Rodet, data from 109, 367, 371. Rodriguez, on capito-collar lengths 362, 363; on crural trough 80; data from 109, 235, 236, 237, 238, 241, 243, 244, 247, 248, 250, 251, 253, 254, 351, 358, 359, 367, 368, 370, 371, 372, 380, 381, 382, 383, 387; on external fossette of anterior face 106; on influence of age on pilastric and platymeric indices 269; on measurements of femoral head 350; on femoral neck 380; on platymeric lateral protrusion 107, 108; on Neolithic man 476. Rollet, data from 237. Ruggieri, data of 251.

Sarasin, data from 251, 253. Schaaffhausen, on Neanderthal man 452. Schenk, data of 238, 240, 251, 358, 371. Schlosser, on evolutionary position of *Dryopithecus rhenanus* 481. Schwalbe, his descent of man 314, 481; his measurement of corpses 41. Schwerz, on association of platymeric and pilastric indices 262; data from 128, 234—236, 239, 240, 244, 246, 247, 251, 254, 370, 371, 390, 393. Scott, data from 235, 237, 246, 250, 251, 253, 387; platymeric index from 7, 104. Sergi, data from 251, 254, 359. Short, data from 238. Sudeck, on facet on neck of femur 91, 92. Sutherland, data of 238.

Tamagnini, capito-collar lengths of 360, 363; femoral correlations from 505, 506; data of 237, 239, 240, 244, 247, 251, 371, 379, 390, 393. Tarenetzky, data of 251. Thane, material from 1; assistance of 3. Thomson, A., on facets of tibia and astragalus 104. Thomson, E. Y., assistance of 2. Thorndyke, on measure of variability 166. Topinard, data from 236, 237, 238. Török, on percentage of anomalies in the two sexes 70; on third trochanter 69, 72. Turner, trochanteric length of 4.

Verneau, data from 246; *Les Grottes de Grimaldi* of 452. Virchow, on third trochanter 69.

Waldeyer, on the pelvis 138; on third trochanter 64, 65, 66. Walkhoff, on facet of neck 92. Walmsley, on determination of axis of neck of femur 21; on collar angle 368, 379; data from 371; on lemotic index in young and adult femora 381, 382. Warren, correlations from memoir on Naqada femora 196—199; data from 236, 243, 370, 371; on fundamental triangle 20, 360, 363, 366; on difference between maximum and oblique lengths 227; on maximum length 33; memoir of on Naqada femora 1; pseudo-obliquity of 31, 32; sexing of Naqada femora 39; variability of Naqada femora 166—173. Weber, on orientation of the pelvis in man 137, 138. Wilbrand, process on femur of 64, 69, 83—86. Wolney, data of 236. Wood-Jones, assistance of 84; on ancestry of man 501, 504. Wortman, data from 250, 254.

Zanolli, data of 358, 359, 371, 375, 390, 407, 412, 417. Zuccarelli, on third trochanter 72—74, 76—78.

II. INDEX TO SUBJECTS

Femoral measurements and Indices for the various primate species accompanied by remarks on anomalies etc. are given in the Tables of Measurements, Atlas II. To save space only the subfamilies, not the species, are included in this Index. The reader seeking the femoral characters of a special ape should refer to those Tables directly.

ACHONDROPLASIA, Plates XIII, XIV, XCIV; see Dwarfs. ADAPIS PARISIENSIS, Plate C, aspalacoid index for 511. ADDUCTOR TUBERCLE, 86, 87. AGE, influence of on bowing 276—278, 306; and gracility 303—305, Plate LVIII; effect on femoral indices 268, 269, 473. AGOUTI, AMERICAN, Plate XXVII, rotular index for 429. AIGTAS OF LUZON, stature of 238. AINOS, bicondylar width in 390; bicondylar width ratio in 392—394; bust ratios in 364—366; capito-collar length in 361; collar angle in 371; distal breadth ratio of 234; epiphysial ratio for 383; and Europeans 128; femoral head for 351, 352, 354, 358—360; major femoral lengths for 313; lemotic index for 380, 381; neck length for 361; platymeric index in 104; robusticity of femur for 248, 251; shaft indices for 253, 265; stature of 238; torsion of 244; variability for 166—170, 173, 174, 185. AKKAS, stature of 238. ALEUTS, robusticity of 248, 251. AMERICANS (born), pilastric index of 270; stature of 236. AMERICAN EUROPEANS, stature of 236. AMERICAN FOSSIL LEMUROIDS, see Notharctus. AMERICAN NEGROES, pilastric index of 270; stature of 236. AMPHIBIANS, pilastric index in 270. ANATOMICAL AXIS OF FEMUR, definition of 230. ANAU FEMORA, bicondylar width in 390; bicondylar width ratio in 393; collar angle in 368, 371; distal breadth ratio in 234; femoral head in 348, 359; obliquity of shaft of 240; pithecoid index of 246; torsion of 243. ANDAMAN FEMORA, Plates XCII, XCIII; aspalacoid index of 511; bicondylar width in 390; bicondylar width ratio in 392—394; distal breadth ratio of 234; head in 347, 348, 352—353, 356, 359; popliteal skewness in 308; popliteal pyramidal index of 307; robusticity of 250; shaft indices in 253, 259, 265, 268, 298, 305; soffit index in 306; stature of 238; indices of taper of 310, 311. ANGLES OF FEMUR, see Collar Angle, Obliquity, Torsion, etc. ANGLO-SAXONS, stature of 236. ANNAMITES, stature of 238. ANOMALIES OF THE FEMUR 62—113; in London series, Atlas I, Tables C, D; in achondroplasia 443; in relation to descent of man 483—485, 487; in primogenial man 453—464; see Plates XXII—XXX, XXXIV—XLI, LVII, LXII, LXV. ANTHROPOID APES (greater), aspect of acetabula in 137—139; and ancestry of man 340—343, 344, 444—464, 479; anomalies in femur of 66, 71, 80, 113, 453, 454; aspalacoid index of 511; band-radial indices of 19, 141, 396—398, 399; bicondylar width of 389—391; bicondylar width ratio of 392—394; bowing of femora of 281, 282, 317, 318, 459—461; bust ratios of 364—366; capito-collar length in 361, 362; collar angle in 282, 368—374; condylar lengths and indices for 17, 403, 405—413, 416, 419, 421—423, 458; consistency of measurements on 450; distal articulation width and indices for 424—428; epiphysial development in 315, 316; epiphysial ratio for 383—385; fovea capitis in 482; gracility in 297, 298, 304, 305, 335, 336, 455 (see also Shaft indices); head of femur in 347—360; interspecial differences of from types of man 491, 494, 496, 498; lemotic index of 378—382; major lengths of femur of 313, 314; midtrochlear angle of 320, 321; femoral neck of 374—377; obliquity of shaft of 319, 320; patellar surface height of 425, 426; orientation of pelvis in 138, 139, figs. iii, iv; pithecoid index of 245—247; pilastric index in 13, 104 (see also Shaft indices); popliteal region of 13, 14, 16, 17, 287, 288, 297, 484—486 (see also Shaft indices); popliteal pyramidal index of 307; popliteal skewness of 308, 309, 332, 333; proximal and distal breadths and ratios of 338, 339, 346, 347; reduced indicial deviations from simio-human 489, 490, 492—500; robusticity of femora of 249, 250; rotular indices and ratios of 428—431, 448, 449; shaft of femur, diameters and indices of 252—255, 258, 259, 265, 282, 325—338; slenderness of femur in 304; soffit index in 306, 333, 334, 457; indices of taper of 309—311, 336. ARMADILLO, aspalacoid index for 511; third trochanter for, Plate XXVII; rotular index for 429. ARTHRITIS in English femora, Plates XV—XVII, XXIX. ARTIODACTYLA, pilastric index of 271. ASPALACOID INDEX, definition of 510; comparative values of 511. ASS, collar angle for 368. ASYMMETRY, see Side of femur. ATELEIOSIS, Plates XCV A and B: see Dwarfs. ATELES, Plates LXXIII, LXXIV, LXXVIII, LXXIX; aspalacoid index of 511; band-radial indices of 396, 397, 399; bicondylar width and ratio of 389, 390, 392, 393; bowing of femur of 317, 318; bust ratio of 364; capito-collar length of 361; collar angle of 370; condylar lengths and indices of 403, 404, 406—408, 412, 413, 416, 419; condylar obliquity of 421, 422; diaphysial rotular ratio of 449; distal articulation indices and width 424, 426, 427, 448; distal breadth ratio for 338, 339; epiphysial development in 315, 316; epiphysial ratio of 383, 384; femoral head of 348, 349, 357; head-bust ratio of 354, 355; lemotic index of 378, 379; major femoral lengths of 313; midtrochlear angle in 320, 321; femoral neck in 361, 375—377; obliquity of shaft of 319; patellar surface height of 425; pithecoid index of 245—247; proximal breadth of 346; proximal breadth ratio of 338, 339; robusticity of femur of 250; rotular indices of 429, 430, 449; shaft diameters and indices of 325, 328, 331, 333, 336; torsion angles of 322, 323. AUSTRALIAN FEMORA, Plates XCVI, XCVII; aspalacoid index of 511; band-radial indices of 396, 399; bicondylar width and ratio of 390—394; characters of 477; collar angle of 367, 368, 370, 371, 477; compared with protsimio-human and dwarf types 434, 435; condylar lengths and indices of 405—407, 417; distal breadth ratio of 234, 235; epiphysial ratio of 383; fovea capitalis lipped, Plates XCVI, XCVII; head of 347—349, 352, 353, 356, 358, 359; head-bust ratios of 354, 364; major lengths of 313; neck of 375, 377; obliquity of shaft of, Plate XCVI; patellar surface height in 425; popliteal pyramidal index of 307; popliteal skewness of 308; proximal breadth of 346; proximal breadth ratio of 232, 233; robusticity of 249, 251; shaft indices in 252, 253, 256, 259, 265, 268, 298, 305, 477; soffit index in 306, 477; stature from 236; indices of taper in 310, 311. AYE-AYE: see Chiromyrdae.

Baboons, Plates LXXXIV—LXXXIX: see Table, Atlas II for measurements and references under Simiadae. Badenser femora, condylar length and index of 405, 407; distal breadth ratio of 234; proximal breadth ratio of 233. Band-radial index, of ape and man 19, 397, 398; comparative table of 396; correlation of with other characters 195, 207, 221, 295—297; definition of 18; mean value in English 116; in primates and man 396—398, 509; in protsimio-human and dwarf types 435, 441, 443; reduced indicial deviation from simio-human for apes and man 497, 498; sexual character in 141, 142, 181; influence of side on 134, 135, 177; standard deviation of in English 163, 189; variability of in English 165. Band-radii, correlation of horizontal and vertical 195, 206, 220; measurement of 18, 19, 395; in protsimio-human and dwarf types 434; influence of sex on 145, 147, 182; influence of side on 130, 131, 132, 175; standard deviation of in English 162; value of in English femora 115, 398; variability of in English 164. Bantu, stature of 236. Barbary ape, Plates LXXX, LXXXI. Basques, capito-collar length of 361; collar angle of 371; femoral head of 351, 359; head-bust ratio of 353—355, 365; lemotic index of 380, 381; femoral neck of 361; robusticity of femora of 251; shaft indices of 254, 265; stature of 238; torsion of femur of 244. Bavarians, bicondylar width and ratio of 390, 393; collar angle of femora of 367, 371; condylar lengths and indices of 405, 407, 417; indices of femoral neck of 375; obliquity of shaft of 240; shaft indices of 254, 262, 263, 265, 298; stature of 237, 238; indices of taper of 310; femoral torsion of 244. Bechuanas, stature of 236. Belgians, anomalies in femora of 67, 68, 72, 75. Berbers femora, bust ratios of 365; capito-collar length of 361; collar angle of 371; crural trough in 80; head of 351, 358, 359; head-bust ratio of 354; lemotic index of 381; major lengths of 313; length of neck in 361; platymeric lateral protrusion in 108; robusticity of 251; torsion of 243. Bicondylar width, see Plate II B; comparative table of 390; correlated with appreciation of sex 148—151, 156; correlation of with other characters 152, 153, 158—160, 193—195, 203, 206—210, 212—214, 216, 217, 220, 221, 283, 284; mean values of for Hepburn's British femora 122; mean value of for English series 115, 122; measurement of 17, 18; in primate femur 446; in primates and man 389—391, 509; in primogenial and recent man 468, 474, 479; in protsimio-human and dwarf types 434; in protsimio-human, ape and recent man 343; racial variabilities in 168; sexual character in 53—56, 145—148, 182; influence of side on 130, 131, 175; standard deviation of in English 162; variability of in English 164. Bicondylar ratio, comparative table of 393; definition of 36; mean value of for Hepburn's British 123; mean value of in English 116, 123; in primates and man 391—394, 509; in primogenial and recent white and negro types 469, 475, 479; in protsimio-human and dwarf types 435, 441, 442; racial values of 234; reduced indicial deviations from simio-human for apes and man 497, 498; sexual difference in 142, 181; influence of side on 133, 134, 177; standard deviation of for English series 163, 188; variability of in English 165. Bicondylar trochanteric index, definition of 38; mean value of in English 116; racial values of 234, 339; sexual difference in 142, 181; influence of side on 134, 177, 178; standard deviation of in English 163, 188; variability of in English 165. Birds, pilastric index in 270. Bolivian femora, capito-collar length in 361; external fossette of anterior face in 106; size of head in 351; lemotic index in 381; length of neck in 361. Bolognese femora, bicondylar width and ratio in 390, 393; collar angle in 371; condylar lengths index in 407; condylar ratios for 417; indices of head in 358, 359; indices of neck in 375. Bowing, see also Primary index of bowing and Secondary index of bowing; in apes' femora 281, 282, 459—461; association of with other characters 282—286, 461; discussion of in young and adult femora 276—287; indices of 36; lateral 306; mean value of indices of for English series 116; methods of measuring 33—36, 277, 460, 461; in primate femur 317—319, 482, 509; in primogenial man 459—462, 502; influence of side on 281; source of 281—287, 459, see also Plates XIV, XXXIII, XXXIV, LIII—LV. Brachyurus, Plate LXXVII; aspalacoid index of 511; band-radial indices of 396, 399; bicondylar width and ratio of 389, 390, 393; bowing of femur of 317, 318; bust ratio of 364; capito-collar length of 361; collar angle of 370; condylar lengths of 404; condylar indices and ratio 406, 407, 412, 416; condylar obliquity of 421, 422; distal articulation indices and width 424, 426, 427; distal breadth ratio of 339; epiphysial development in 315; epiphysial ratio of 383; femoral head of 348, 357; head-bust ratio of 354; lemotic index of 378; major femoral lengths of 313; midtrochlear angle of 321; femoral neck in 361, 375—377; obliquity of shaft in 319; patellar surface height in 425; pithecoid index in 246; proximal breadth of 346; proximal breadth ratio of 339; robusticity of femur of 250; rotular ratio and index of 429, 430; shaft diameters and indices of 325, 328, 331, 333, 336; torsional angles in 322, 323. British femora, modern, bicondylar width and ratio of 390, 391, 393; distal breadth ratio of 234; size of head in 348; popliteal pyramidal index of 307; popliteal section of 12, 13; popliteal skewness of 308; shaft indices of 254, 256, 265, 298, 305; soffit index of 306; stature from 236; indices of taper of 310, 311. Bronze-age Europeans, bust ratio in 365; capito-collar length of 361; collar angle of 371; femoral head in 351, 358, 359; head-bust ratio of 354; lemotic index of 380, 381; femoral neck in 361; robusticity of femur of 251; shaft indices of 254, 265; stature of 238; torsion angle of 244. Burgundians, bust ratio of 365; capito-collar length of 361; collar angle of 371; femoral head of 351, 358, 359; head-bust ratio of 354; lemotic index of 381; femoral neck of 361; robusticity of femur of 251; shaft indices of 254, 265; torsion angle of 244. Bushman, Plates XCII, XCIII; aspalacoid index of 511; bicondylar width and ratio of 390, 393, 394; popliteal skewness in 308; robusticity of femur of 250; stature of 238. Bust-shaft index, definition of 37; mean value of in English 116; in primogenial and recent man 341; in primogenial and recent white and negro types 469, 479; in protsimio-human 385; in protsimio-human and dwarf types 435, 439, 440; reduced indicial deviation from simio-human for apes and man 494, 495; sexual differences in 142, 181; influence of side on 134, 177, 178; standard deviation of in English 163, 188; variability of in English 165; racial variabilities in 172.

Californian femora, capito-collar length in 361; external fossette of anterior face in 106; size of head in 351; lemotic index in 381; length of neck in 361. Calipers, error in reading of 186, 187. Callithrix, Plates LXXVIII, LXXIX, measurement Table, Atlas II. Canary Islanders, anomalies in femora of 67, 68, 69; bust ratio for 365; capito-collar length in 361; collar angle in 371; femoral head of 351, 358, 359; head-bust ratio of 354; lemotic index of 381; length of femoral neck of 361; robusticity of femur of 251; shaft indices of 254, 258, 265; stature of 237; torsion angle of 244. Canidae, American, condylar indices of 412, 413; condylar lengths index of 407, 410. Capital angle, mean value of in English 115; measurement of 19—22; in primogenial and recent man 468; in protsimio-human, ape and recent man 343; in protsimio-human and dwarf types 434, 436; sexual differences in 136, 140, 147, 179; influence of side on 131, 132, 176; standard deviation of in English 162, 190; variability

of in English 164, 176, 190. CAPITAL RATIO, comparative tables of in primates and man 348, 351, 509; definition of 38; mean value of in English 116, 123; in primogenial and recent man 341; in primogenial and recent white and negro types 469, 475, 479; in protsimio-human 385; in protsimio-human and dwarf types 435, 439, 440; racial values of 352, 353; reduced indicial deviations from simio-human of apes and man 494, 495; sexual differences in 142, 181; influence of side on 134, 177; standard deviation of in English 163, 189; variability of in English 165. CAPITO-BICONDYLAR INDEX, comparative table of 348; definition of 39; mean value of in English 116, 123; in primates and man 348, 385, 509; in primogenial and recent white and negro types 469, 475; in protsimio-human 385; in protsimio-human and dwarf types 435, 439; racial values of 353; reduced indicial deviation from simio-human of apes and man 494, 495; sexual differences in 141, 142, 181; influence of side on 134, 177; standard deviation of in English 163, 189; variability of in English 165. CAPITO-COLLAR LENGTH, comparative table of 361; correlation of with other characters 193—195, 197, 199, 203, 206—210, 212—214, 216, 218, 221, 283, 284, 505, 507; mean value of in English 115; measurement of 20, 197, 198, 360—363, Plates I, II; effect of paralysis on 109; in primates and man 360—362, 509; in primogenial and recent man 468, 479; in protsimio-human and dwarf types 434; racial variabilities in 168; sexual differences in 145—147, 182; influence of side on 130, 131, 175; standard deviation of in English 162; variability of in English 164. CAPITO-TROCHLEAR LENGTH, mean value of in English 115; measurement of 20, Plate I; in primogenial and recent man 468; in protsimio-human, ape and recent man 343; in protsimio-human and dwarf types 434; sexual difference in 145, 147, 182; influence of side on 130, 131, 175; standard deviation of in English 162; variability of in English 164. CARIBBEANS, stature of 236. CARLOVINGIANS, collar angle of 370. CARNIVORA VERA, aspalacoid index of 511; pilastric index in 271. CAROLINE ISLANDERS FEMORA, bicondylar width and ratio in 390, 393; distal breadth ratio of 234; proximal breadth for 346; proximal breadth ratio of 233. CARTHAGINIANS, bust ratios in 365; capito-collar length of 361; collar angle of 371; femoral head of 351, 359; head-bust ratio of 354; lemotic index of 381; length of neck of 361; robusticity of femur of 251; shaft indices of 254, 265; stature of 237; torsion of 244. CAT'S FEMUR, rotular index of 429. CEBIDAE, aspalacoid index of 511; band-radial indices of 396, 397, 399; bicondylar width in 389, 390; bicondylar ratio in 392—394; bowing in 317—319, 482; bust ratios in 364—366; capito-collar length in 361, 362; collar angle of 369, 370; condylar lengths of 403, 404; condylar lengths index of 406—408, 458; condylar indices of 412, 413; condylar ratios of 416, 419; condylar obliquity of 421, 422; distal articulation width of 424, 425; distal articulation indices 426—428; epiphysial development of 315, 316; epiphysial ratio of 383, 384; femoral head of 348, 349, 355—357; head-bust ratio of 353, 354; lemotic index of 378—380; major femoral lengths of 313, 314; midtrochlear angle in 320, 321; femoral neck of 361, 374—377; obliquity of shaft in 319; patellar surface height of 425, 426; place in Haeckel's pedigree of primates 480; pilastric index of 271 (see also Shaft indices); pithecoid index of 245—247; proximal breadth of 346, 347; proximal and distal breadth ratios of 338, 339; robusticity of femur in 249, 250; rotular ratio and index 429—431; shaft diameter and indices 325—331, 333—337; torsion angles of 322—324. CEBUS, Plates LXXIII, LXXIV C; aspalacoid index of 511; band-radial indices of 396, 399; bicondylar width and ratio of 389, 390, 393; femoral bowing in 317; bust ratios in 364; capito-collar length in 361; collar angle in 369, 370; condylar lengths and indices 404, 406, 407, 412, 416; condylar obliquity of 421; distal articulation width and indices 424—428; epiphysial development of 315; epiphysial ratio of 383; femoral head of 348, 349, 357; head-bust ratio of 354; lemotic index of 378; major femoral lengths of 313; midtrochlear angle of 321; femoral neck of 361, 375, 376; obliquity of 319; patellar surface height in 425, 426; pithecoid index of 246; proximal breadth of 346, 347; proximal and distal breadth ratios of 339; robusticity of femur of 250; rotular ratio and index of 429—431; shaft diameters and indices of 325, 328, 331, 333, 336; torsional angles of 322, 323. CERCOCEBUS, Plates XC and XCI, references as for Simiadae. CERCOPITHECUS, Plates LXXX—LXXXIX, references as for Simiadae. CERVICAL ANGLE, see Collar angle. CHARLES' FACET, history of study of in man 104—106; origin of 112, see Plates XXII, XXIX, XXX. CHIMPANZEE, Plates XLIII, XLIV, XCVIII A, XCVIII B; femoral anomalies in 454; aspalacoid index of 511; band-radial indices for 396, 399; bicondylar width and ratio 389, 390, 392, 393; femoral bowing in 281, 282, 317, 460; bust ratios in 364—366; capito-collar length in 361; collar angle of 282, 368—370; condylar lengths of 17, 405; condylar indices and ratios of 406, 407, 412, 416, 419; condylar obliquity of 421, 423; distal articulation width of 424, 425; distal articulation ratio and index 426—428; distal breadth ratio 234, 338, 339; epiphysial development in 315, 316; epiphysial ratio of 383; evolutionary position of 343, 344, 356, 362, 366, 369, 376, 385, 386, 409, 432, 480, 481, 501—504; gracility of femur of 298, 305, 336, 455 (see also Shaft indices); femoral head of 348, 349, 357; head-bust ratio of 354, 355; interspecial differences of from types of man 491, 494, 496, 498; lemotic index of 378; major femoral lengths of 313, 314; midtrochlear angle of 320, 321; femoral neck of 361, 375—377; obliquity of shaft of 240, 282, 319, 320; patellar surface height of 425, 426; pithecoid index of 245—247; popliteal curvature of 13, 14, 16, 287, 288, 484—486; popliteal index 16 (see also Shaft indices); popliteal pyramidal index of 307; popliteal skewness of 308, 333; proximal breadth of 346, 347; proximal breadth ratio of 233, 338, 339; reduced indicial deviations from simio-human 489, 490, 492, 493—500, diagrams 490, 493, 495, 497, 499; robusticity of femur of 250; rotular index and ratios 429—431, 449; shaft indices of 253, 258, 265, 282, 325, 327—331, 333, 336; soffit index for 306, 333, 457; indices of taper of 309, 310, 336—338; torsional angles of 241, 243, 282, 322, 324. CHINESE, bicondylar width and ratio of 390, 392—394; bust ratios in 365, 366; capito-collar length of 361, 362; collar angle of 370; epiphysial ratio of 383; femoral head of 351, 356, 358; head-bust ratio of 354, 355; lemotic index of 381; length of neck of 361; popliteal skewness of 308, 309; robusticity of femur of 251; stature of 237, 238; torsion of 244. CHIROPTERA, aspalacoid index of 511; pilastric index of 271. CHIROMYRDAE, Plates LXXXII, LXXXIII; aspalacoid index of 511; band-radial indices of 396, 399; bicondylar width and ratio of 390, 393; bowing in 317, 318; bust ratio in 364; capito-collar length in 361; collar angle in 370; condylar lengths and indices of 404, 406, 407, 412, 416; condylar obliquity of 421; distal articulation measurements and indices 339, 424, 426, 427; epiphysial development in 315; epiphysial ratio in 383; femoral head of 348, 357; head-bust ratio of 353, 354; lemotic index of 378; major femoral lengths of 313; midtrochlear angle of 320, 321; femoral neck of 361, 375, 377; obliquity of shaft of 319; patellar surface height of 425; pithecoid index of 246; proximal breadth of 346; proximal breadth ratio of 339; robusticity of femur 250; rotular ratios and index 429, 430; shaft diameters and indices of 325, 328, 331, 333, 336, 337; torsional angles of 322. CHRYSOTHRIX SCIUREA, Plates LXXV, LXXVI: see references for Cebidae. CLAVICLE, variability in 185. COAXIAL POINT OF FEMUR, Plates I, II; determination of 20, 214, 215, 360, 363. COEFFICIENT OF VARIATION 161,

166; use in determining correlation coefficient 193, 196, 218; for diaphysial length 229; racial differences in 166—174; racial values of for torsional angle 241; sexual differences in 179—184; table of for indices of English femora 165; table of for measurements on English femora 164; table of for chief long bones of skeleton 185. Collar angle, correlation of with other characters 194, 198, 199, 205—207, 216—218, 221, 282, 285, 372, 505, 507; mean value of in English 115; measurement of 20—22, 117, 366—368, Plates X, XXX; as measured by Lehmann-Nitsche 127; as measured by Parsons 125; in primates and man 366—374, 509; in primogenial and recent man 341, 468, 474, 476, 477, 479; in protsimio-human, ape and recent man 343; in protsimio-human and dwarf types 434, 436; in relation to presence of Poirier's facet 94, 95; sexual difference in 136, 140, 147, 179, 180; influence of side on 131, 132, 176, 217; in sound and paralysed limbs 109, 110; standard deviation of in English 162, 190; variability of in English 164, 190; comparative variabilities in 170, 171; in young bones 110, 111. Colobus, Plates LXXVIII, LXXIX; Table of measurements, Atlas II, references as for Simiadae. Columbians prehistoric, femoral bowing of 279, 280; stature of 238. Comparative femoralogical study, difficulties of 114, 119, 122—128. Condylar index, comparative table of 412; definition of 39; mean value of in English 116; in primates and man 411—413, 509; in protsimio-human and dwarf types 435, 441, 442; reduced indicial deviations from simio-human for apes and man 497, 498; sexual difference in 142, 143, 180, 181; influence of side on 134, 177, 178; standard deviation of in English 163, 189; variability of in English 165. Condylar lengths, comparative table of 403—405; correlation of with other characters 194, 195, 206, 208, 209, 210; differences between internal and external 17, 402; mean value of in English 115; measurements of 18, 394, 400, 401; in primates and man 400—406, 509; in protsimio-human and dwarf types 434; relative size of 458; sexual differences in 145, 147, 182; influence of side on 130—132, 175; standard deviation of in English 162; variability of in English 164. Condylar lengths index, comparative table of 406, 407; correlation of with pilastric index 195, 206, 207; definition of 39, 406; mean value of in English 116; in primates and man 406—411, 509; in protsimio-human and dwarf types 435, 441; reduced indicial deviation from simio-human in apes and man 497, 498; sexual differences in 142, 143, 181; influence of side on 134, 177; standard deviation of in English 163; for Trinil femur 17, 406; variability of in English 165. Condylar obliquity index, comparative table of 421; definition of 420, 422; in primates and man 421—423. Condylar ratios, comparative table of 416, 417; definitions of 414; interchanging factors for 415; in primates and man 416—420, 509. Condylar trochanteric index, see also Condylar ratios; definition of 38; mean value of in English 116; in protsimio-human and dwarf types 435, 441; reduced indicial deviation from simio-human in apes and man 497, 498; sexual difference in 142, 180, 181; influence of side on 134, 135, 177; standard deviation of in English 163, 188; variability of in English 165. Condyles, axis of 25, 26, 27, 29; band-radii of external 18, 19; contour of 26; correlation of length of with sex appreciation 148, 149, 157; correlation of length of with other characters 152, 153, 159, 160, 193—195, 206, 208—210, 212, 220, 221; mean values of lengths of in English 115; measurement of lengths of 18, Plate III; sexual difference in 145—148, 182; influence of side on 131, 132, 175; standard deviation of lengths of in English 162; variability of in English 164. Congolese, bust ratios in 365; capito-collar length of 361; size of femoral head of 351; lemotic index of 381; length of femoral neck of 361. Correlation, of presence of anomalies of femur in same bone 68, 75, 76, 81, 82, 83, 89, 100, 101; of presence of anomalies of femur in paired bones 77, 78; of presence of anomalies of femur with indices of femur 79, 96—99, 102, 104; of bowing of femur with other characters 283—286; of characters in the English femur, its comparison with that of other races and other bones and the influence of side and sex 192—224, 283—286, 505—508; of collar angle with other characters 372, 373, 505, 507; comparison of two methods of determining 193, 196; comparison of femoral with those of other bones 202—204; distribution of in parts of femur 211—224; of lengths of femur with other characters 5, 266, 267, 505, 507; interracial 264—268, 282; interspecial 372, 373; method of determining for Antony and Rivet's data 507; of popliteal curvature with other characters 289—296; racial comparisons in 196—202, 505—508; of different sexings of femora 57, 59, 60; of appreciation of sex with various characters 148—151; of chief sexually differentiated femoral characters 152, 153; influence of sex on 204—211, 217; of shaft indices with other characters 79, 102, 104, 260—268, 300, 303, 505, 507; influence of side on 202—204; spurious 300, 302; tables, concerning sexual characters 156—160. Crista trochanterica 66, 69. Cromagnon femora, Plates LV—LVII; anomalies in 106, 108, 453, 454; aspalacoid index for 511; bicondylar width and ratio in 389, 392; bowing in 317, 318, 459—461, 467; bust ratios in 365, 366; capito-collar length of 361, 362; character of 467—470, 474, 475; collar angle of 368, 369; comparative table of measurements and indices of 341; compared with other types 467—470, 473—475, 479; distal articulation index of 427, 428; distal articulation ratio of 426; distal articulation width of 424, 425; epiphysial ratio of 383, 384; evolutionary position of 340, 341, 463, 464, 470, 477—479, 502; gracility in 455 (see also Shaft indices of); head of 348, 349, 351, 352, 355, 356, 358, 360; head-bust ratio of 353—355; lemotic index of 378, 380, 381; major lengths of 313, 314; midtrochlear angle of 321; neck of 361; obliquity of 319, 320; patellar surface height in 425, 426; pilaster in 459, 461, 463, 467 (see also Shaft indices of); pithecoid index of 246; popliteal curvature in 484, 485; popliteal skewness of 308, 333; proximal breadth of 346; proximal and distal breadth ratios of 338, 339; robusticity of 249, 250; rotular indices of 428—430; shaft indices of 253, 258, 265, 298, 305, 325, 327—331, 333, 335, 336; soffit index of 306, 334, 457, 458; stature from 236; indices of taper of 309—311, 336—338; torsional angles of 243, 467, 468, 474. Crural trough, in achondroplasic femur 443; association of in paired bones 78; association of with other anomalies 81, 82, 83; history of study of in man and animals 80—83; in primogenial man 454; in protsimio-human 342; sexual percentages of in Naqada femora 81; Plates XXXVII, XLI. Cynocephalus, Plates LXXXVIII, LXXXIX; aspalacoid index of 511; band-radial indices of 396, 397, 399; bicondylar width and ratio of 390, 393; bowing in 317, 318; bust ratios of 364; capito-collar length in 361; collar angle of 370; condylar lengths and indices of 404, 406, 407, 412, 416; condylar obliquity of 421; distal articulation widths and indices 424, 426, 427; epiphysial development of 315, 316; epiphysial ratio of 383; femoral head of 348, 357; head-bust ratio of 354; lemotic index of 378; major lengths of 313; midtrochlear angle of 320, 321; femoral neck of 361, 375—377; obliquity of shaft of 319; patellar surface height in 425; pithecoid index of 246; proximal breadth of 346; proximal and distal breadth ratios of 339; robusticity of femur of 250; rotular indices of 429—431; shaft diameters and indices of 325, 327, 328, 331, 333, 336; torsional angles of 322.

Dasyprocta, third trochanter in Plate XXVII; rotular index of 429. Dasypus sexcinctus, aspalacoid index of 511; third trochanter in Plate XXVII; rotular index of 429. Deer, collar angle of 368. Degenerates,

asymmetry in 128; prevalence of third trochanter in femur of 72, 73, 76. DIAGRAMS, showing frequency distribution for diameter of head, trochanteric oblique length, popliteal length and bicondylar width for male and female femora 45, 50, 52, 53; showing comparisons of cranial and femoral correlations 201; showing comparison of male and female correlations 204; of pilastric cross sections 255; of popliteal section in apes, primogenial and recent man 485, 486; showing racial correlation of shaft indices 265; of reduced indicial deviations from protsimio-human of apes and man 490, 493, 495, 497, 499. DIAPHYSIAL CHORD, in measurement of bowing 36; mean value of for English 115; correlation of with diaphysial subtense 195, 206, 207, 221; in primogenial and recent man 468; in protsimio-human and dwarf types 434; sexual difference in 145—147, 182; influence of side on 130, 131, 175; standard deviation of in English 162; variability of in English 164. DIAPHYSIAL CHORD SEGMENT, in measurement of bowing 36; mean value of in English 115; in primogenial and recent man 468; in protsimio-human and dwarf types 434. DIAPHYSIAL LENGTH, comparative values of 313; mean values of 228; measurement of 228, 229; in primates 312—314; in protsimio-human, ape and recent man 343; in protsimio-human and dwarf types 434; use of 228, 229; variability of 229. DIAPHYSIAL ROTULAR RATIO, comparative table of 429; definition of 449; in fossil lemuroids 509; in primogenial and recent man 341, 428, 429, 448, 449; in protsimio-human and dwarf types 435, 441, 442; reduced indicial deviations from protsimio-human for apes and man 497, 498. DIAPHYSIAL SUBTENSE, in measurement of bowing 36; correlation of with diaphysial chord 195, 206, 207, 221; in fossil lemuroids 509; mean value of in English 115; in primogenial and recent man 468; in protsimio-human and dwarf types 434; sexual difference in 145, 147, 182; influence of side on 131, 132, 175; standard deviation of in English 162; variability of in English 164. DIAPHYSIO-EPIPHYSIAL INDEX, in man and primates 314—317. DISTAL ARTICULATION INDEX, comparative table of 427; definition of 427, 448; in primogenial and recent man 341, 427, 428, 448, 469; in protsimio-human and dwarf types 435, 441, 442; reduced indicial deviations from protsimio-human for apes and man 497, 498. DISTAL ARTICULATION RATIO, comparative table of 426; definition of 448; in primates and man 426, 427, 509; in primogenial and recent man 469; in protsimio-human and dwarf types 435; reduced indicial deviations from protsimio-human for apes and man 497, 498. DISTAL ARTICULATION WIDTH, comparative table of 424; correlation of with other characters 505; measurement of 448; in primates and man 424, 425, 509; in primogenial and recent man 468, 474; in protsimio-human and dwarf types 434. DISTAL BREADTH RATIO, comparative values of 234, 339; definition of 231, 232; for primate femur 338, 339, 509; in primogenial and recent man 469, 475, 479; in protsimio-human ape and recent man 343; in protsimio-human and dwarf types 435, 437; reduced indicial deviations from protsimio-human for apes and man 489. DOLMENS FOLK, collar angle for 370; index of neck for 375; robusticity of femora of 251; stature of 237. DRYOPITHECUS RHENANUS = Pliohylobates Eppelsheimensis, Plate LXVI; aspalacoid index of 511; band-radial indices of 396, 397, 399; bicondylar width and ratio of 389, 390, 392, 393; femoral bowing in 317, 482; bust ratios of 364, 365; capito-collar length of 361, 362; characters of 410; collar angle in 369, 370; condylar lengths of 403, 404; condylar lengths index of 406, 408—410, 458; condylar indices and ratios of 412, 413, 416, 419; condylar obliquity of 421, 422, 423; distal articulation width and indices 424, 425, 426—428; epiphysial development in 315, 316; epiphysial ratio of 383, 384; evolutionary position of 340, 480, 481; gracility in 335, 336 (see also Shaft indices); femoral head of 348, 349, 355—357, 360; head-bust ratio 354, 355; interspecial differences of from types of man 491, 494, 496, 498; lemotic index of 378, 379; major lengths of 313, 314; midtrochlear angle of 320, 321; femoral neck of 361, 374—377; obliquity of shaft of 319, 320; patellar surface height of 425, 426; pithecoid index of 246; popliteal curvature in 484, 486; popliteal skewness in 308, 332, 333; proximal breadth of 346, 347; proximal and distal breadth ratios of 338, 339; reduced indicial deviations from protsimio-human 489, 490, 492—500; robusticity of femur in 249, 250; rotular indices of 428—430, 449; shaft diameters and indices of 16, 253, 325—333; soffit index of 333, 334; indices of taper of 310, 336, 337; torsional angles of 322—324. DWARFS, Plates XIII, XIV; femoral angles of 436; and ancestry of man 443, 444; anomalies in achondroplasic 443; indices of bust of 439—441; comparative table of characters for different types of 434, 435; indices of distal epiphysis of 441—443; femur of 433—443; general indices of 436, 437; obliquity of shaft of 240; robusticity of femur of 251; indices of shaft of 437—439; stature of 238; torsional angle of 244.

EDENTATA, aspalacoid index for 511; pilastric index in 271. EGYPTIANS, femoral anomalies in 75, 78, 81—84, 88, 89, 93, 100, 101, 106; fossa hypotrochanterica in Plate LXII; bust ratios in 365; capito-collar length of 361; collar angle of 371; correlations of 197—199; femoral head of 357, 358, 359; head-bust ratio of 354; lemotic index of 380, 381; femoral neck of 361; pilastric index of 270; robusticity of 248, 250; stature of 237; torsional angles of 243; variability of 167—169, 173. ELLIPTICITY OF HEAD, comparative tables of 357—359; definition of 37; mean value of in English 116; in primates and man 356—360, 509; in primogenial and recent white and negro types 469; in protsimio-human 385; in protsimio-human and dwarf types 435, 439, 440; reduced indicial deviation from protsimio-human for apes and man 494, 495; sexual differences in 142, 143, 181; influence of side on 134, 177, 178; standard deviation of in English 163, 189; variability of in English 165. ELLIPTICITY OF NECK, comparative table of 375; correlation of with other characters 95—98, 194, 195, 203, 206, 209, 221, 285, 372, 373, 507; definition of 23, 37; mean value of in English 116; in primates and man 374—376, 509; in protsimio-human, ape and man 385; in protsimio-human and dwarf types 435, 439, 440; reduced indicial deviation from protsimio-human for ape and man 494, 495; sexual difference in 142, 144, 181; influence of side on 134, 135, 177, 178; standard deviation of in English 163, 189; variability of in English 165. ELLIPTO-PILASTRIC INDEX, definition of 256, 257. ENGLISH FEMORA, anatomical axis of 230; anomalies in 75, 79, 81, 82, 84, 88, 93—102, 106, 107, 108; asymmetry in 129—135; band-radial indices in 396, 397, 399; bicondylar width and ratio in 389, 390, 392, 393; bowing in 280, 317, 460; bust ratios in 364, 365; capito-collar length in 361, 362; collar angle in 369, 370; comparison of with other races and influence of side and sex 114—160; comparison of with other British series 122—127; compared with Cromagnon, Grimaldi and recent Negro types 467—471, 474, 475, 477, 478; compared with Neanderthal man and Galley Hill man 477, 478, 479; condylar lengths and indices of 403, 405—408, 412, 413; correlation of characters in, its comparison with that of other races and other bones and influence of side and sex 192—224, 263; distal articulation width and indices 424, 426, 427; epiphysial development in 315; epiphysial ratio of 383, 384; gracility in 298, 305, 336, 455; head in 348, 352, 355, 356, 358, 359; head-bust ratio in 354; interspecial differences of types of man and ape from 491, 494, 496, 498; lemotic index of 378, 379; major lengths of 228, 313; mean value of measurements on tabled 115; mean value of indices tabled 116; midtrochlear angle of 321; neck of 361, 374, 375, 377; obliquity of 240, 319; patellar surface height in 425, 426; pathological condition of 2; pilaster in 460

(see also Shaft indices); pithecoid index of 246; popliteal pyramidal index of 307; popliteal skewness of 308, 333; proximal breadth of 346; proximal and distal breadth ratios of 339; reduced indicial deviations from protsimio-human 489, 490, 492—500; robusticity of 251; rotular indices of 429, 430; sexual differences in 135—160; shaft indices in 254, 259, 263, 265, 325, 328, 331, 333, 336; soffit index of 306, 333, 457; source of 1, 2; standard deviations of 162, 163; stature from 6, 236, 237; indices of taper of 309, 310, 336; torsional angles of 244, 322, 324; variability of, its comparison with that of other races and other bones and influence of side and sex 161—191. EPIPHYSIAL DEVELOPMENT in man and primates 314—317. EPIPHYSIAL RATIO, comparative table of 383; definition of 37; mean value of in English 116; in primates and man 382—385, 509; in primogenial and recent man 341, 469, 475, 479; in protsimio-human 385; in protsimio-human and dwarf types 435, 439, 441; reduced indicial deviations from protsimio-human of apes and man 494, 495; sexual difference in 142, 180, 181; influence of side on 134, 177, 178; standard deviation of in English 163, 189; variability of in English 165. EPPELSHEIM FEMUR, see Dryopithecus rhenanus. ESKIMO FEMORA, bicondylar width and ratio of 390, 391—394; bust ratios in 365; capito-collar length of 361, 362; collar angle of 371; distal breadth ratio of 234; epiphysial ratio of 383; femoral head of 351, 352, 356, 358, 360; head-bust ratio of 354; lemotic index of 381; femoral neck of 361; popliteal pyramidal index of 307; popliteal skewness of 308; robusticity of 248, 251; shaft indices of 254, 265, 298, 305; soffit index of 306; stature of 238; indices of taper of 310, 311; femoral torsion of 243. ESTHONIANS, stature of 237. ETRUSCANS, ANCIENT, femoral head of 359; robusticity of femur of 251; shaft indices of 254. EUROPEAN FEMORA, anomalies in 70—72, 106; aspalacoid index of 511; difference in condylar lengths of 17. EUROPEAN FOSSIL LEMUROID: see Adapis parisiensis.

FABELLAE: see Sesamoids. FACET OF NECK, see Poirier's Facet. FELIDAE, AMERICAN, condylar indices of 412, 413; condylar lengths index in 407, 410. FELLAHS, stature of 236. FIBULA, variability in 185. FINNS, stature of 236. FOETAL FEMORA, Plate LIX; bowing in 278, 306; gracility in 303—305; lemotic index in 381; pilastric index in 270; popliteal diameters in 12; slenderness in 304. FORMULAE, for correlation of indices 299; for interchange of condylar ratios 415; for partial correlation coefficients 300—302; for passing from oblique to maximum length 226; for reconstruction of stature 5, 235. FOSSA ANGULOLATERALIS, and ancestry of man 483, 484; in gorilla and chimpanzee, Plates XLII, XLIV, LXII; relationship of to fossa hypotrochanterica 483, 484, Plate LXII. FOSSA HYPOTROCHANTERICA, and ancestry of man 483, 484; association of with other anomalies 67, 75, 81, 100, 107, 483, 484; association of with platymery 79; history of study of in man and animals 65—80; in primogenial man 453; in protsimio-human 342; sexual character of 70, 74, 75; sexual percentages of in Naqada femora 82, 83; influence of side on 74, 76, 77, 78, see Plates XXIX, XXXV, XXXVI, LVII. FOSSA OF POSTERIOR FACE IN APES, see Remarks to Tables of Measurements, Atlas II, Plates LXXVII, XCI, etc. FOSSETTE EXTERNAL OF ANTERIOR FACE, see Plates XXXIV, XL; description of 106. FOSSIL LEMUROIDS, Plates C A—B. FOURTH TROCHANTER 69, Plate XXVII; in wild goose, Plate XLI; ?in Barbary Ape and in Palaeomastodon, Plate LXVIII. FOVEA, of femoral head in apes and man 482, 483; lipped in Australians, Plate XCVII. FRANKS, bust ratio in 365; capito-collar length in 361; collar angle of 371; femoral head of 351, 358, 359; head-bust ratio of 354; lemotic index of 381; robusticity of femur of 251; shaft indices of 254, 265; stature of 237; torsional angles of 244. FRENCH FEMORA, MEDIAEVAL, bust ratio of 365; capito-collar length of 361; collar angle of 371; head of 351, 358, 359; head-bust ratio of 354; lemotic index of 381; length of neck of 361; popliteal measurements on 16; shaft indices of 254, 265; stature from 236, 237; torsion angle of 244. FRENCH FEMORA, MODERN, anomalies and their associations in 76, 80, 106, 108; bust ratios in 364, 365; capito-collar length of 361; collar angle in 109, 367, 370, 371; compared with English 127; head of 348, 351, 358; head-bust ratio of 354; lemotic index of 381; neck of 361, 375; robusticity of 247, 251; shaft indices of 254, 265; torsion of 244; variability in lengths of 166, 167. FRENCH LONG BONES, stature from 237; variability of 185. "FRINGE" RACES, characters of 391, 476, 477. FRONTAL PILASTER in Man, Lion, Kangaroo and Lemuroids, Plates LXV, LXXI. FUEGIANS, anomalies in femora of 71, 72, 104; aspalacoid index of 511; bicondylar width and ratio of 390—393; capito-collar length of 361, 362; collar angle of 368, 370; condylar lengths and ratios of 405, 417; distal breadth ratio of 234; epiphysial ratio of 383; femoral head of 348, 351—353, 356, 358; head-bust ratio of 354, 355; lemotic index of 381; major femoral lengths of 313; femoral neck of 361, 375, 376; obliquity of 240; pithecoid index of 246; platymeric index of 104, 477 (see also Shaft indices); proximal breadth of 346; proximal breadth ratio of 233; robusticity of 248, 251; shaft indices of 254, 258, 265, 477; stature of 238; torsion angle of 243. FUNDAMENTAL TRIANGLE OF FEMUR, determination and measurement of 19—22.

GALAGINAE, Plates LXIX—LXXIII; aspalacoid index of 511; band-radial indices of 396, 399; bicondylar width and ratio 390, 393; bowing of femur in 317, 318; bust ratios in 364; capito-collar length in 361; collar angle in 369, 370; condylar lengths and indices 404, 406, 407, 412, 416; condylar obliquity of 421—423; distal articulation width and indices 424, 426, 427; epiphysial development in 315, 316; epiphysial ratio of 383; femoral head of 348, 357; head-bust ratio 354; lemotic index of 378; major femoral lengths of 313, 314; midtrochlear angle of 321; femoral neck in 361, 375, 377; obliquity of shaft of 319; patellar surface height in 425; pithecoid index of 246; proximal breadth of 346; proximal and distal breadth ratio of 339; robusticity of femur in 250; rotular ratios of 429—431, 448, 449; shaft diameters and indices of 325, 327, 328, 330, 331, 333, 336, 337; torsional angles of 322. GALLEY HILL FEMUR, Plates LX, LXI; age of 456; anomalies in 453, 454, 456; bicondylar width and ratio in 389—393, 479; bowing of 317, 461; bust ratios of 365, 366, 479; capito-collar length of 361, 479; characters of 478, 479; collar angle of 368—370, 479; compared with Neanderthal, Cromagnon and recent man types 478, 479; condylar lengths and indices of 405, 417; condylar obliquity of 421, 423; distal breadth ratio of 234, 479; epiphysial ratio of 383, 384, 479; evolutionary position of 341, 342, 478, 479; gracility of 298, 305, 336, 455, 456; head of 348, 352, 355, 356, 358, 479; head-bust ratio of 353—355, 479; lemotic index of 378, 380; major lengths of 313, 479; midtrochlear angle of 321; neck of 361, 375—377, 479; Newton on 451; obliquity of 240, 319, 320, 479; pilaster of 461, 478; pithecoid index of 246; popliteal curvature in 484, 486; popliteal pyramidal index of 307; popliteal skewness of 308, 333; proximal breadth of 346, 479; proximal and distal breadth ratios of 233, 339, 479; robusticity of 249, 250, 479; shaft diameters and indices of 325, 328, 329, 331, 333, 336; soffit index of 306, 333, 457, 458; indices of taper of 310, 311, 336; torsional angles of 322, 479. GAULS, ANCIENT, bust ratios in 365; capito-collar length 361; collar angle of 371; femoral head of 351, 358, 359; head-bust

ratio of 354; lemotic index of 381; length of femoral neck 361; robusticity of 251; shaft indices of 254, 265; stature of 236; torsion angle of 244. GERMAN FEMORA, anomalies in 88; bust ratios in 365; capito-collar length of 361; collar angle of 367, 371; condylar ratios of 417; head of 351, 358; head-bust ratio of 354; lemotic index of 381; length of neck of 361; robusticity of 247, 251; shaft indices of 254, 259; stature of 236; torsional angle of 244. GIANTS, stature of 236. GIBBON FEMORA, comparison with *Dryopithecus*, Plate LXVI; and ancestry of man 340, 343, 344, 356, 366, 369, 385, 386, 428, 432, 479—504; aspalacoid index of 511; band-radial indices of 396, 397, 399; bicondylar width and ratio 389, 390, 392, 393; bowing in 282, 317, 318, 460, 461, 482; bust ratios in 364—366; capito-collar length in 361, 362; collar angle of 282, 368—370; condylar lengths and indices of 403, 405—408, 412, 413, 416, 419; condylar obliquity of 421, 422; distal articulation width and indices 424—428; distal breadth ratios of 234, 338, 339; epiphysial development in 315, 316; epiphysial ratio of 383, 384; gracility in 298, 305, 335, 336, 455 (see also Shaft indices of); head of 348, 349, 355—357; head-bust ratio of 353—355; interspecial differences from types of man 491, 494, 496, 498; lemotic index of 378—380; major lengths of 313, 314; midtrochlear angle of 320, 321; neck of 361, 374—377; obliquity of 240, 282, 319, 320; patellar surface height of 425; pilaster of 461, 482; pithecoid index of 245—247; popliteal curvature of 484, 485; popliteal pyramidal index of 307; popliteal skewness of 308, 333; proximal breadth of 346, 347; proximal breadth ratios of 233, 338, 339; reduced indicial deviations from simio-human 489, 490, 492—500; robusticity of 249, 250; rotular indices of 428—430, 449; shaft indices of 253, 258, 259, 265, 282, 325—328, 330—336; soffit index of 306, 333, 334, 457; indices of taper of 309, 310, 336, 337; torsional angles of 322—324, see Plate XLV. GILBERT ISLANDERS' FEMORA, condylar lengths of 17, 405; condylar lengths index in 407; distal breadth ratio of 234; proximal breadth ratio of 233. GIRTH, of head of femur 36; of femur 36. GONIOMETER, 30, 31. GOOSE FEMUR, fourth trochanter in, Plate XLI. GORILLA, anomalies in 454; aspalacoid index of 511; band-radial indices of 396, 397, 399; bicondylar width and ratio in 390, 391, 393; bust ratios in 364, 365; capito-collar length in 361; collar angle of 282, 368—370; condylar lengths of 17, 405; condylar indices and ratios of 406, 407, 412, 416; condylar obliquity of 421, 423; distal articulation width and indices 424, 426, 427; distal breadth ratio of 234, 339; epiphysial development in 315, 316; epiphysial ratio of 383; evolutionary position of 480, 481; femoral bowing in 281, 282, 317, 460; fossa angulolateralis of 483; gracility of 298, 305, 335, 336, 455; femoral head of 348, 349, 357; head-bust ratio of 354; interspecial differences of from types of man 491, 494, 496, 498; lemotic index of 378; major lengths of 313; midtrochlear angle of 320, 321; femoral neck of 361, 375, 377; obliquity of shaft of 240, 282, 319, 320; patellar surface height of 425; pithecoid index of 245, 246; popliteal curvature of 13, 14, 16, 287, 288, 332, 484—486; popliteal pyramidal index of 307; popliteal skewness of 308, 332, 333; proximal breadth of 346; proximal breadth ratio of 233, 338, 339; reduced indicial deviations from simio-human of 489, 490, 492—500; robusticity of 249, 250; rotular indices of 429, 430; shaft indices of 252, 253, 256, 258, 259, 265, 325, 327, 328, 331, 333, 335, 336; soffit index of 306, 333, 457; indices of taper of 309, 310, 336—338; torsion angles of 241, 243, 282, 322, 324, see also Plates XLII, XLIX—LVII. Infant, Plate XCIX. GRIMALDI FEMORA, anomalies in 454; aspalacoid index of 511; bicondylar width and ratio in 389, 390, 392, 393, 468, 474, 475; bowing in 317, 469; bust ratios in 475; capito-bicondylar ratio of 475; capital ratio of 475; characters of 471—475; collar angle of 369; compared with Cromagnon and recent white and negro types 468, 469, 471—475; distal articulation width and indices of 424—427, 468, 475; epiphysial ratio of 383, 384, 475; evolutionary position of 475; gracility of 455, 456, 474; femoral head of 348, 351, 352, 358, 359, 469, 474, 475; lemotic index of 378, 469, 475; major lengths of 313, 468; midtrochlear angle of 321; obliquity of shaft of 319, 320, 468; patellar surface height of 425; pithecoid index of 246; popliteal index of 474 (see also Shaft indices); proximal breadth of 346, 468; proximal and distal breadth ratios of 339, 469; robusticity of 249, 250, 469; rotular indices of 429, 430; shaft indices of 253, 325, 327, 328, 331, 333, 336, 469; soffit index in 457, 474. GROWTH, in relative proportions, Plate LVIII. GRUBER'S PROCESS, in man and lion, Plate LXVIII. GUANCHES, anomalies in femur of 72, 76, 80, 108; bicondylar width and ratio of 390, 393, 394; bust ratio in 365; capito-collar length of 361; collar angle in 368, 371; and Cromagnon femora 477; epiphysial ratio of 383; femoral head of 351, 352, 358, 359; head-bust ratio of 354; lemotic index of 380, 381; major lengths of 313, 314; femoral neck of 361, 375; popliteal skewness of 308; robusticity of 251; shaft indices of 254, 258, 265; stature of 237; torsion of 243.

HAND, variability in bones of 188. HAPALEMUR GRISEUS, Plates LXXI, LXXII. HAPALINAE, aspalacoid index of 511; band-radial indices of 396, 399; bicondylar width and ratio of 390, 393; femoral bowing of 317; bust ratios in 364; capito-collar length in 361; collar angle of 370; condylar lengths and indices of 404, 406, 407, 412, 416; condylar obliquity of 421, 422; distal articulation width and indices of 424, 426, 427; epiphysial development in 315, 316; epiphysial ratio of 383; femoral head of 348, 357; head-bust ratio of 354; lemotic index of 378; major lengths in 313, 314; midtrochlear angle of 321; femoral neck in 361, 375, 377; obliquity of shaft of 319; patellar surface height in 425; pithecoid index of 246; proximal breadth of 346; proximal and distal breadth ratios of 339; robusticity of 250; rotular indices of 429, 430; shaft diameters and indices of 325, 328, 331, 333, 336; torsional angles of 322, 323. HEAD OF FEMUR, angle of with femoral neck 36; centre of 19, 20; comparative tables of diameters and indices of 348, 351, 354, 357—359; diameters of correlated with appreciation of sex 148, 149, 156; correlation of diameters of with other characters 152, 153, 158, 160, 193—195, 203, 206—214, 220, 221, 505; ellipticity of 37 (see Ellipticity of head); girth of 36; mean diameters of in English 115; measurement of diameters of 7, 446, Plates I, II; modified by fracture of acetabula 112; in primates and man 347—360, 509; in primogenial and recent man 468, 474, 476, 479; in protsimio-human 342; in protsimio-human and dwarf types 434; robusticity of 39 (see Robusticity of head); sexual differences in 41—56, 145—148, 182; influence of side on 130—132, 175; in sound and paralysed limbs 110; standard deviation of diameters of in English 162; variability in diameters of in English and other races 164, 168. HEAD-BUST RATIO, comparative table of 354; definition of 37; (first capito-collar index) mean value of in English 116; in primates and man 353—355, 509; in primogenial and recent white and negro types 469, 479; in protsimio-human 385; in protsimio-human and dwarf types 435, 439, 440; reduced indicial deviations from simio-human of apes and man 494, 495; sexual difference in 142, 181; influence of side on 134, 177; standard deviation of in English 163, 189; variability of in English 165. HEMIPLEGIA, torsion in case of, Plates XCV A, XCV B. HESPERORNIS REGALIS, fourth trochanter in, Plate XXVII. HINDOO FEMORA, bust ratios in 365; capito-collar length of 361; collar angle of 371; distal breadth ratio of 234; epiphysial ratio of 383; head of 348, 351, 352, 359; head-bust ratio of 354; lemotic index of 381; length of neck of

361; proximal breadth ratio of 233; robusticity of 250; shaft indices of 253, 265; stature from 238; torsion of 244. Homo aurignacensis (Hauseri), bicondylar width and ratio of 390, 392, 393; femoral bowing of 317; bust ratio of 365; capito-collar length of 361; collar angle of 368, 370; comparative table of measurements and indices of 341; distal articulation width and indices of 424, 426, 427; distal breadth ratio of 339; epiphysial ratio of 383, 384; evolutionary position of 341, 342; gracility of 298, 305, 336, 455; femoral head of 348, 358; head-bust ratio of 354; lemotic index of 378, 380; major lengths of 313; midtrochlear angle of 321; femoral neck of 361, 375, 377; obliquity of shaft of 240, 319; patellar surface height of 425; pithecoid index of 246; proximal breadth of 346; proximal breadth ratio of 339; robusticity of 249, 250; rotular indices of 428—430; shaft indices of 325, 328, 331, 333; soffit index of 306, 333, 457, 458; index of proximal taper of 310, 336. Homo mousteriensis (Hauseri), Plate XLVII; anomalies in 453, 454; aspalacoid index of 511; bicondylar width and ratio of 390, 393; femoral bowing in 460; bust ratios of 365; capito-collar length of 361; collar angle of 370; condylar lengths and indices of 405, 407, 417; condylar obliquity of 421; convexity of popliteal surface of 15, 484, 486; distal breadth ratio of 234; epiphysial ratio of 383; gracility of 455; femoral head of 348, 358; head-bust ratio of 354; Klaatsch on 452; lemotic index of 378; femoral neck of 361, 375, 377; obliquity of shaft of 240; popliteal measurements on 16; popliteal pyramidal index of 307; popliteal skewness of 308; proximal breadth ratio of 233; shaft indices of 253, 298, 305; soffit index of 306, 457; femoral torsion of 243; size compared with orang and recent man, Plates LXIII, LXIV. Hottentots, stature of 238. Humerus, variability in 185. Hyena striata, condylar indices of 407, 412. Hyracoidea, pilastric index in 271.

Index of distal taper, comparative values of 309, 310; definition of 309; in primates and man 335—337, 509; in primogenial and recent white and negro types 469; in protsimio-human, ape and recent man 343; in protsimio-human and dwarf types 435, 438; reduced indicial deviations from simio-human in apes and man 492, 493. Index of gracility (lower), comparative values of 298; correlation of with other characters 194, 195, 203, 205—207, 219, 222, 291, 292, 300, 301, 303; definition of 38; discussion of 297—305; influence of growth on 303; mean value of in English 116, 123; in primates and man 334—336, 509; in primogenial and recent man 455, 456, 469; in protsimio-human, ape and recent man 343; in protsimio-human and dwarf types 435, 438, 439; reduced indicial deviations from simio-human in apes and man 492, 493; sexual difference in 141, 142, 181; influence of side on 134, 135, 177, 178; standard deviation of in English 163, 189; variability of in English 165. Index of gracility (upper), comparative values of 305; definition of 38; mean value of in English 116, 123; in primates and man 334—336, 509; in primogenial and recent man 341, 469, 474; in protsimio-human, ape and recent man 343; in protsimio-human and dwarf types 435, 437, 438; reduced indicial deviations from simio-human for apes and man 492, 493; on sexual difference in 141, 142, 181; influence of side on 134, 135, 177; standard deviation of in English 163, 189; variability of in English 165. Index of means, its agreement with mean index 120, 121. Index of popliteal skewness, comparative values of 307—309; correlation of with convexity of popliteal area 195, 207, 222, 289—291, 297; definition of 38; mean value of in English 116, 124; in primates and man 332—334, 509; in protsimio-human, ape and recent man 343; in protsimio-human and dwarf types 435, 437, 438; reduced indicial deviations from simio-human in apes and man 492, 493; sexual difference in 141, 142, 181; influence of side on 134, 177; standard deviation of in English 163, 189; variability of in English 165. Index of proximal taper, comparative values of 309, 310; definition of 309; in primates and man 336—338, 509; in primogenial and recent man 469, 474; in protsimio-human, ape and recent man 343; in protsimio-human and dwarf types 435, 438; reduced indicial deviations from simio-human in apes and man 492, 493. Index of sagittal slenderness, definition of 38; mean value of in English 116; in primates and man 328, 330, 509; in primogenial and recent man 469; in protsimio-human, ape and recent man 343; in protsimio-human and dwarf types 435, 437, 438; as racial characters 141; reduced indicial deviations from simio-human in apes and man 492, 493; sexual difference in 142, 181; influence of side on 133—135, 177, 178; standard deviation of in English 163, 189; variability of in English 165. Index of transverse slenderness, definition of 38; influence of growth on 304; mean value of in English 116; in primates and man 328, 330, 509; in primogenial and recent man 341, 469; in protsimio-human, ape and recent man 343; in protsimio-human and dwarf types 435, 438, 439; as racial characters 141; reduced indicial deviations from simio-human in apes and man 492, 493; sexual difference in 142, 181; influence of side on 134, 177; standard deviation of in English 163, 189; variability of in English 165. Indians, American, anomalies in femora of 106, 108; bust ratios in 365; capito-collar length of 361; collar angle of 370; distal breadth ratio of 234; femoral head of 351, 358; head-bust ratio of 354; lemotic index of 380, 381; major lengths of 313; femoral neck of 361; obliquity of femoral shaft of 240; pithecoid index of 246; proximal breadth ratio of 233; robusticity of femora of 250, 251; shaft indices of 104, 254, 265, 270; stature of 236, 238; femoral torsion of 243, 244. Indices of femur, description of 36—39, etc.; mean values of in English 116; sexual difference in 141—144, 180, 181; influence of side on 133—135, 177, 178; standard deviations of in English 163; variability of in English 165; comparative variabilities in 171, 172; variability of compared with those of indices of the skull 188, 189. Indo-Chinese, bust ratios of 365; capito-collar length of 361; collar angle of 371; femoral head of 351, 352, 358, 359; head-bust ratio of 354; lemotic index of 381; major lengths of 313; length of femoral neck of 361; robusticity of 250; stature of 238; torsion angles of 244. Indonesians, bust ratios in 365; capito-collar length of 361; collar angle of 371; femoral head in 351, 358, 359; lemotic index of 381; length of femoral neck of 361; robusticity of 251; torsional angles of 243. Indrisinae, aspalacoid index of 511; band-radial indices of 396, 397, 399; bicondylar width and ratio of 390, 393; femoral bowing in 317, 318; bust ratios in 364; capito-collar length of 361; collar angle in 370; condylar lengths and indices of 404, 406, 407, 412, 416, 458; condylar obliquity of 421; distal articulation width and indices of 424, 426, 427, 448; epiphysial development in 315, 316; epiphysial ratio of 383; femoral head of 348, 357; head-bust ratio of 353, 354; lemotic index of 378; major lengths of 313, 314; midtrochlear angle in 321; femoral neck in 361, 375, 377; obliquity of shaft of 319; patellar surface height of 425; pithecoid index of 246; proximal breadth of 346; proximal and distal breadth ratios of 339; robusticity of 250; rotular indices of 429, 430; shaft diameters and indices of 325, 328, 331, 333, 336, 337; torsional angles of 322. Infant, man, gorilla, orang, chimpanzee, Plates XCVIII A—B, XCIX. Insectivora, aspalacoid index of 511; pilastric index in 271. Interspecial differences, definition of 489; for man and apes

from *Pithecanthropus*, Neanderthal and Recent Man 491, 494, 496, 498. IRISH FEMORA, robusticity of 251. ITALIANS, anomalies in femora of 76; stature of 237, 238. See also BOLOGNESE.

JACCHUS, Plates LXXV, LXXVI: see Hapalinae. JAPANESE FEMORA, bicondylar width and ratio of 390, 392–394; bust ratios in 364—366; capito-collar length of 361; collar angle of 368, 371; crural trough in 80; difference of from Europeans 128; distal breadth ratio of 234; epiphysial ratio of 383; femoral head of 351, 352, 356, 358, 359; head-bust ratios of 354; lemotic index of 380, 381; femoral neck of 361; proximal breadth ratio of 233; robusticity of 248, 251; shaft indices in 253, 258, 265; stature from 238; torsional angles of 244. JAVANESE FEMORA, condylar lengths of 17, 405; condylar indices of 407, 417; distal breadth ratio of 234; proximal breadth ratio of 233. JUAGS, stature of 238.

KABYLES, stature of 237.

LAGOTHRIX, Plates LXXIII, LXXIV; aspalacoid index of 511; band-radial indices of 396, 399; bicondylar width and ratio of 390, 393; femoral bowing of 317, 318; bust ratios in 364; capito-collar length of 361; collar angle of 370; condylar lengths and indices of 404, 406, 407, 412, 416; condylar obliquity of 421; distal articulation width and indices of 424, 426, 427; epiphysial development of 315; epiphysial ratio of 383; femoral head of 348, 357; head-bust ratio of 354; major lengths of 313; midtrochlear angle in 320, 321; femoral neck in 361, 375, 377; obliquity of 319; patellar surface height of 425; pithecoid index of 246; as primitive type 373, 374; proximal breadth of 346; proximal breadth ratio of 339; robusticity of 250; rotular indices of 429, 430; shaft diameters and indices of 325, 327, 328, 331, 333, 336; torsional angles of 322, 323. LAPLANDERS, bicondylar width and ratio of 390, 391, 393, 394; bust ratios of 365, 366; capito-collar length of 361; collar angle of 371; distal breadth ratio of 234; epiphysial ratio of 383; femoral head of 351, 352, 356, 358, 359; head-bust ratio of 353, 354; lemotic index of 380, 381; length of femoral neck of 361; popliteal skewness of 308; robusticity of femora of 248, 251; shaft indices of 254, 259, 265; stature of 238; torsional angles of 244. LATERAL PROTRUSION of anterior face: see Protrusion, platymeric. LEMOTIC INDEX, comparative tables of 378, 381; in foetus and non-adult femora 381, 382; in fossil lemuroids 509; in primogenial and recent man 341, 378—382, 469, 475; in protsimio-human 385; in protsimio-human and dwarf types 435, 439, 440; reduced indicial deviation from simio-human in apes and man 494, 495; sexual character of 379, 380, 382. LEMURINAE, Plates LXIX—LXXII; aspalacoid index of 511; band-radial indices of 396, 399; bicondylar width and ratio of 390, 393; femoral bowing in 317, 318; bust ratios of 364; capito-collar length in 361; collar angle of 370; condylar lengths and indices of 404, 406, 407, 412, 416, 421; distal articulation width and indices of 424, 426—428; epiphysial development in 315, 316; epiphysial ratio of 383; femoral head of 348, 357; head-bust ratio of 353, 354; lemotic index of 378; major lengths of 313, 314; midtrochlear angle of 320, 321; femoral neck of 361, 375, 377; obliquity of femur of 319; patellar surface height of 425; pithecoid index of 246; proximal breadth of 346; proximal and distal breadth ratios of 339; robusticity of femur of 250; rotular indices of 429, 430, 448, 449; shaft diameters and indices of 325, 328, 331, 333, 336, 337; torsional angles of 322, 323. LEMUROIDEA, anomalies in 454, 482; aspalacoid index in 511; band-radial indices in 396, 397, 399; bicondylar width and ratio of 389, 390, 392—394; femoral bowing in 317—319, 482; fossil, 508—512; bust ratios in 364—366; capito-collar length of 361, 362; collar angle of 369, 370; condylar lengths and indices of 403, 404, 406—408, 412, 413, 416, 419, 421, 422, 458; distal articulation width and indices of 424—428; epiphysial development of 315, 316; epiphysial ratio of 383, 384; evolutionary position of 340, 480, 482, 483; fossil 508—512; in Haeckel's pedigree of primates 480; femoral head of 348, 349, 353, 355—357, 360; head-bust ratio of 353—355; lemotic index of 378—382; major lengths of 313, 314; midtrochlear angle in 320, 321; femoral neck in 361, 374—377; obliquity of shaft of 319; patellar surface height in 425, 426; pilastric index of 271; pithecoid index of 245—247; proximal breadth of 346; proximal and distal breadth ratios of 338, 339; robusticity of femur of 249, 250; rotular indices of 428—431; shaft diameters and indices of 253, 264, 265, 325—337; torsional angles of 322—324. LENGTH OF FEMUR (MAXIMUM), asymmetry in 129; comparative values of 313; correlation of with other characters 193, 194, 199, 203, 206—209, 212, 213, 218, 219, 266, 284; difference between oblique length and 226, 227; mean value of in English 115; measurement of 4, Plate I; effect of paralysis on 109; in primates 312—314, 509; in primogenial and recent man 468, 474, 476, 479; in protsimio-human 342, 343; in protsimio-human and dwarf types 434; racial variabilities in 167; reconstruction of stature from 5, 226, 227; sexual difference in 54, 55, 145, 147, 182; sex-ratio of 144; influence of side on 130, 131, 133, 175; standard deviation of in English 162; variability of in English 164. LENGTH OF FEMUR (OBLIQUE), asymmetry in 129; correlation of with other characters 194, 197, 206—208, 212, 267, 268, 505, 507; difference between maximum length and 226, 227; in fossil lemuroids 509; mean value of in English 115, 122; measurement of 4, 5, Plate I; effect of paralysis on 109; in primogenial and recent man 468, 476, 479; in protsimio-human, ape and recent man 343; in protsimio-human and dwarf types 434; racial variabilities in 168; reconstruction of stature from 5, 226, 227; sexual difference in 42—47, 145—148, 182; sex-ratio of 145; influence of side on 130, 131, 133, 175; standard deviation of in English 162; variabilities of in English 164. LINEA ASPERA, index of 256, 257. LION'S FEMUR, rotular index of 429; Gruber's process in, Plate LXVII. LITHUANIANS, stature of 236. LIVERPOOL STREET FEMORA, compared with Whitechapel series 2. LIVONIANS, stature of 236. LONDON FEMORA, see English. LORISINAE, Plates LXIX, LXX; band-radial indices of 396, 399; bicondylar width and ratio of 389, 390, 393; femoral bowing in 317, 318; bust ratios in 364; capito-collar length of 361; collar angle of 370; condylar lengths and indices of 404, 406, 407, 412, 416, 421, 422, 458; distal articulation width and indices of 424—428; epiphysial development in 315; epiphysial ratio of 383; femoral head of 348, 349, 357; head-bust ratio of 353, 354; lemotic index of 378; major lengths of 313, 314; midtrochlear angle in 321; femoral neck of 361, 375—377; obliquity of shaft of 319; patellar surface height of 425; pithecoid index of 246; proximal breadth of 346, 347; proximal and distal breadth ratios of 339; robusticity of 250; rotular indices of 429—431; shaft diameters and indices of 325, 327, 328, 330, 331, 333, 336, 337; torsional angles of 322, 323.

MACACUS, Plates LXXX, LXXXI, LXXXVI—LXXXIX; aspalacoid index of 511; band-radial indices of 396, 399; bicondylar width and ratio of 390, 393; femoral bowing in 317; bust ratios in 364; capito-collar length of 361; collar angle of 369, 370; condylar lengths and indices 404, 406, 407, 412, 416, 421; distal articulation width and

indices 424, 426, 427, 448; epiphysial development of 315, 316; epiphysial ratio of 383; femoral head of 348, 357; head-bust ratio of 354; lemotic index of 378; major lengths of 313; midtrochlear angle of 320, 321; femoral neck of 361, 375, 377; obliquity of shaft of 319; patellar surface height of 425; pithecoid index of 246; robusticity of 250; rotular indices of 429, 430; proximal breadth of 346; proximal and distal breadth ratio of 339; shaft diameters and indices of 325, 327, 328, 331, 333, 336; torsional angles of 322. MALAY FEMORA, bust ratios in 365, 366; capito-collar length of 361, 362; collar angle of 368, 371; condylar lengths and indices of 17, 407, 417, 419; distal breadth ratio of 234; epiphysial ratio of 383; head of 351, 352, 356, 358—360; head-bust ratio of 354, 355; lemotic index of 381; length of neck of 361; popliteal skewness of 308, 309; proximal breadth ratio of 233; robusticity of 250; shaft indices in 253, 265; stature from 238; torsion of 244. MAN OF LA CHAPELLE-AUX-SAINTS, anomalies in femur of 453, 454; aspalacoid index of 511; bicondylar width and ratio of 390, 393; Boule on 451; femoral bowing of 460, 461; bust ratios of 365; capito-collar length of 361; collar angle of 370; condylar lengths and indices of 405, 407, 412, 417; epiphysial ratio of 383, 384; gracility of 298, 305, 455; femoral head of 348, 358; head-bust ratio of 354; lemotic index of 378; length of neck of 361; obliquity of 240; pilaster in 460; popliteal pyramidal index of 307; soffit index of 306, 457; indices of taper of 310. MAN OF LA FERASSIE, anomalies in femur of 453, 454; aspalacoid index of 511; torsional angles of 243. MAORI FEMORA, bicondylar width and ratio of 390—393; bowing in 280; bust ratios of 365, 366; capito-collar length of 361; collar angle of 368, 371; distal breadth ratio of 234; epiphysial ratio of 383; gracility of 298, 305; head of 347, 348, 352, 353, 356, 358—360; lemotic index of 380, 381; major lengths of 313; length of neck of 361; obliquity of shaft of 240; pithecoid index of 246; platymery in 104, 253, 258, 477; popliteal pyramidal index of 307; popliteal skewness of 308; robusticity of 250, 251; shaft indices of 252, 253, 259, 265, 477; soffit index of 306; stature from 237; indices of taper of 310, 311; torsional angles of 128, 243. MARSUPIALIA, aspalacoid index of 511; pilastric index in 271. MEAN VALUES OF INDICES FOR ENGLISH FEMORA, 116; comparison of with index of means 120, 121. MEAN VALUES OF MEASUREMENTS ON ENGLISH FEMORA, 115; asymmetry in 128—135; compared with other British series 122—127; compared with those of other races 127, 128, etc.; differences in associated with sex 135—160. MEASUREMENTS ON HUMAN FEMORA, see Atlas I, Sheet I—XIII; criticism of 446, 447, etc.; description of 3—36, 448; function of 257—301; instruments used 3; mean values of in English 115; need for standardisation in 28, 114, 117—119, 128, 360, 363, 366—368, 374, 378—382, 388, 414, 446, 450. MEASUREMENTS ON PRIMATE FEMORA, Atlas II, Tables I and II. MELANESIANS, bust ratios of 365, 366; capito-collar length of 361, 362; collar angle of 368, 371, 372; femoral head of 351, 356, 358, 359; head-bust ratio of 354; lemotic index of 381; length of femoral neck of 361; robusticity of femur of 250; shaft indices of 253, 265; stature of 237; torsional angles of 243. MENDELIAN scheme of heredity 223, 224. MEROVINGIANS, anomalies in femur of 67, 68; bust ratios in 365; capito-collar length in 361; collar angle of 371; femoral head of 351, 359; head-bust ratio of 354; lemotic index of 381; length of femoral neck of 361; robusticity of femora of 251; shaft indices of 254, 260, 265; stature of 237; torsional angles of 244. MIDAS, Plates LXXV, LXXVI, LXXX, LXXXI. MIDTROCHLEAR ANGLE, mean value of in English 115; measurement of 19—22; in primates 320, 321; in primogenial and recent man 341, 468; in protsimio-human, ape and recent man 343; in protsimio and dwarf types 434, 436; sexual difference in 136, 140, 147, 179; influence of side on 131, 132, 176; standard deviation of in English 162, 190; variability of in English 164, 190. MOLDEVINS, stature of 237. MONKEYS, aspalacoid index of 511; band-radial indices of 396—398, 399; bicondylar width and ratio of 389—391, 392—394; femoral bowing in 317—319; bust ratios of 364—366; capito-collar length in 361, 362; collar angle of 369—374; condylar lengths and indices of 403, 404, 406—413, 416, 419, 421—423, 458; distal articulation width and indices of 424—428; distal breadth ratios of 338, 339; epiphysial development in 314—317; epiphysial ratio of 383—385; femoral head of 347—360; lemotic index of 378—382; major lengths of 313, 314; midtrochlear angle in 320, 321; femoral neck of 374—377; obliquity of shaft of 319, 320; patellar surface height of 425, 426; pithecoid index in 245—247; proximal breadth of 346, 347; proximal and distal breadth ratios of 338, 339; robusticity of 249, 250; rotular indices of 428—431, 448, 449; shaft diameters and indices of 253, 264, 265, 325—338; torsional angles of 321—325. MONOTREMATA, aspalacoid index of 511; pilastric index in 271. MORIORI, major lengths of 313; pithecoid index of 246; platymeric index in 104, 253, 258; robusticity of 248, 251; shaft indices of 252, 253, 265, 305; stature of 237; index of proximal taper of 310. MOZAMBIQUE FEMORA, bust ratios in 365; capito-collar length in 361; head of 351; lemotic index in 381; length of neck of 361. MUSCULARITY, association of with femoral tubercles 62—73, 89, 112; need for measurement of 58; as source of bowing 281—285; as source of pilaster 108, 263, 332; as source of popliteal curvature 288. MYCETES, Plates LXXIII, LXXIV; aspalacoid index of 511; band-radial indices of 396, 399; bicondylar width and ratio of 390, 393; femoral bowing of 317, 318; bust ratios in 364; capito-collar length of 361; collar angle in 370; condylar lengths and indices of 404, 406, 407, 412, 416, 421; distal articulation width and indices of 424, 426—428; epiphysial development of 315; epiphysial ratio of 383; femoral head of 348, 357; head-bust ratio of 354; lemotic index of 378; major lengths of 313; midtrochlear angle in 320, 321; femoral neck in 361, 375—377; obliquity of 319; patellar surface height in 425; pithecoid index of 246; proximal breadth of 346; proximal and distal breadth ratios of 339; robusticity of 250; rotular indices of 429—431; shaft diameters and indices of 325, 328, 331, 333, 336; torsional angles of 322, 323.

NAQADA FEMORA, anomalies in 78; bust ratios of 32, 365; capito-collar length in 361; collar angle of 370, 371; correlations of 197—199; difference in maximum and oblique lengths of 227; neck length of 361; pseudo-obliquity of 31; sexing of 59, 60; influence of side in 129; and skeletons 1; stature from 236; torsional angles of 128, 243; variability in 167—173, 185. NEANDERTHAL MAN, Plates LI—LIII; anomalies in 453, 454; band-radial indices of 396, 397, 399; aspalacoid index of 511; bicondylar width and ratio of 389—393; femoral bowing of 317, 318, 459—461, 482; bust ratios of 365, 366; capito-collar length of 361, 362; collar angle of 368—370; comparative table of measurements and indices of 341; condylar lengths and indices of 17, 403, 405—409, 412 413, 417, 419, 421—423, 458; distal articulation width and indices of 424—428, 448; distal breadth ratio of 234, 338, 339; epiphysial development in 315, 316; epiphysial ratio of 383, 384; evolutionary position of 340—342, 344, 463, 464, 477—482, 502, 503; femoral head of 348, 349, 352, 353, 355, 356, 358, 360; head-bust ratio of 353—355; interspecial difference of types of man and ape from 491, 494, 496, 498; Klaatsch on 452; lemotic index of 378—380; major lengths of 313, 314; midtrochlear angle of 321; femoral neck of 361, 375—377;

obliquity of 240, 319, 320; patellar surface height of 425, 426; pilaster in 460, 461 (see also Shaft indices of); pithecoid index of 246; popliteal curvature of 332, 333, 484, 485; popliteal pyramidal index of 307; popliteal skewness of 308, 332; popliteal width of 9, 10; proximal breadth of 346; proximal breadth ratio of 233, 338, 339; reduced indicial deviations from simio-human of 489, 490, 492—500; femoral robusticity of 249, 250; rotular indices of 428—430, 449; shaft indices of 253, 258, 259, 265, 298, 305, 325, 327—333, 336—338, 455; soffit index of 292, 306, 333, 334, 457, 458; stature of 237; indices of taper of 309—311, 336—338; torsional angles of 241, 243, 322, 324. Neck of femur, Plates I, II, X; axis of 19—21, 27, 214, 215; comparative table of lengths of 361; correlation of measurements on with other characters 148, 149, 153, 157—160, 193, 194, 202, 203, 206—210, 213—218, 220; indices of 23, 37; length of 21, 22, 213, 215—217, 361; in fossil lemuroids 509; mean diameters of in English 115; measurement of diameters of 23; effect of paralysis on 109; in primogenial and recent man 468, 474, 479; in protsimio-human and dwarf types 434; sex-ratios of 144; sexual differences in 145—148, 182, 379; influence of side on 130—132, 175; standard deviation of diameters of in English 162; variability of in English 164, see also Ellipticity of neck, Secondary index of neck. Negrito femora, bust ratios of 365; capito-collar length of 361; collar angle of 368, 371, 372; condylar lengths and indices of 17, 405, 407, 417, 419; distal breadth ratio of 234; epiphysial ratio of 383; head of 351, 352, 358, 359; head-bust ratio of 354; lemotic index of 381; length of neck of 361; proximal breadth ratio of 233; robusticity of 250; shaft indices of 253, 265, 268; stature from 238; indices of taper of 310; torsion of 243. Negro femora, anomalies in 67, 68, 76, 80, 106, 108; bicondylar width and ratio of 390, 391, 393, 394; bust ratios in 365, 366; capito-collar length in 361, 362; characters of 471, 472, 474, 475; collar angle in 368, 371, 372; compared with Grimaldi negroid, Cromagnon and recent white types 468—475; condylar lengths of 405; distal breadth ratio of 234, 235; epiphysial ratio of 383; head of 347, 348, 351—353, 356, 358—360; head-bust ratio of 354; lemotic index of 381; major lengths of 313; neck of 361, 375, 376; popliteal pyramidal index of 307; popliteal skewness of 308; proximal breadth of 346; robusticity of 248, 250; shaft indices of 252, 253, 258, 259, 265, 298, 305; soffit index of 306; stature from 236; indices of taper of 310; torsion of 243, 244. Neolithic femora, anomalies in 80, 106, 108; bicondylar width and ratio of 390, 393; bust ratios in 365; capito-collar length of 361; character of 476, 477; collar angle of 370, 371; compared with modern French femora 128; evolutionary position of 476; head of 348, 351, 358, 359; head-bust ratio of 354; lemotic index of 381; major lengths of 313, 314; neck in 361, 377; obliquity of 240; pithecoid index of 246; platymeric index of 104 (see also Shaft indices of); robusticity of 251; shaft indices of 254, 258, 260, 265; stature from 236, 238; torsion of 243, 244. Non-adult bones, see Young femora. Norwegians, stature of 236. Notharctus osborni and tenebrosus, Plates C A—B; characters and indices of 508—512. Nubians, stature of 236. Nycticebus, Plates LXIX, LXX. Nyctipithecinae, Plates LXXVIII, LXXIX; aspalacoid index of 511; band-radial indices of 396, 399; bicondylar width and ratio of 390, 393; femoral bowing in 317; bust ratios in 364; capito-collar length in 361; collar angle in 370; condylar lengths and indices of 404, 406, 407, 412, 416, 421; distal articulation width and indices of 424, 426, 427; distal breadth ratio of 339; epiphysial development in 315; epiphysial ratio of 383; femoral head of 348, 357; head-bust ratio of 354; lemotic index of 378; major lengths of 313; midtrochlear angle in 321; femoral neck of 361, 375, 377; obliquity of shaft of 319; patellar surface height of 425; pithecoid index of 246; proximal breadth ratio of 339; robusticity of 250; rotular indices of 429—431; shaft diameters and indices of 325, 328, 331, 333, 336; torsional angles of 322, 323.

Oblique-direct lengths index, definition of 38; for fossil lemuroids 509; mean value of in English 116; in primogenial and recent man 469; in protsimio-human, ape and recent man 343; in protsimio-human and dwarf types 435, 436; reduced indicial deviations from simio-human in ape and man 489; for Rothwell femora 126; sexual difference in 32, 33, 142, 181; influence of side on 133, 134, 177; standard deviation of in English 163, 188; variability of in English 165. Oblique-direct trochanteric index, definition of 38; for fossil lemuroids 509; mean value of in English 116; in primogenial and recent man 469; in protsimio-human, ape and recent man 343; in protsimio-human and dwarf types 435, 436; sexual difference in 142, 180, 181; influence of side on 134, 177, 178; standard deviation of in English 163, 188; variability of in English 165. Obliquity of shaft, 29; correlation of with other characters 194, 199, 203, 205—207, 212, 217—219, 282, 285, 505; mean value of in English 115; measurement of 30, 31, 239; in primates and man 319, 320, 509; in primogenial and recent man 468, 476, 479; in protsimio-human, ape and recent man 343; in protsimio-human and dwarf types 434, 436; racial values of 125, 127, 240; sexual difference in 32, 136, 140, 147, 179, 239, 240; influence of side on 131, 132, 176, 217, 239, 240; in sound and paralysed limbs 110; standard deviation of in English 162, 190; variability of in English 164, 190; comparative variabilities in 170, 171. Obliquity of shaft, pseudo, 31—33, 239; mean value of in English 115; in primogenial and recent man 468; in protsimio-human and dwarf types 434; sexual difference in 31. Orang-utan, Plates XLIII, XLIV; anomalies in 454; aspalacoid index of 511; band-radial indices of 396, 397, 399; bicondylar width and ratio of 390, 393; femoral bowing of 282, 317, 460; bust ratios of 365; capito-collar length of 361; collar angle of 282, 368—370; condylar lengths and indices of 405—407, 412, 416, 421; distal articulation width and indices of 424, 426, 427, 448; distal breadth ratio of 234, 339; epiphysial development in 315, 316; epiphysial ratio of 383; evolutionary position of 480, 481; gracility of 336, 455; femoral head of 348, 349, 357; head-bust ratio of 353—355; interspecial difference from in types of man 491, 494, 496, 498; lemotic index of 378; major lengths of 313, 314; midtrochlear angle of 321; femoral neck of 361, 375, 377; obliquity of 240, 282, 319; patellar surface height of 425; pithecoid index of 245—247; popliteal curvature of 287, 288, 484—486; popliteal pyramidal index of 307; popliteal skewness of 308, 333; proximal breadth of 346, 347; proximal breadth ratio of 233, 339; reduced indicial deviations from simio-human of 489, 490, 492—500; robusticity of 250; rotular indices of 429, 430, 449; shaft diameters and indices of 253, 258, 265, 282, 298, 305, 325, 328, 331, 333, 336; soffit index of 306, 333, 457; indices of taper of 309, 310, 336, 337; torsional angles of 241, 243, 282, 322, 324. Ostiahs, stature of 238.

Paired bones, association of anomalies in 77, 78. Palaeolithic man, collar angle in 369; stature of 238: see Primogenial man. Paltacalo Indians, bust ratios of 364; collar angle of 370; femoral correlations of 507; femoral neck index of 375. Panjabi femora, Charles's facet in 105. Paralysis, effect of on bones 109—111. Patagonians,

anomalies in, Plate XLI, 106; bust ratios in 365; capito-collar length in 361; collar angle of 371; femoral head of 351, 352, 358; head-bust ratio of 354; lemotic index of 381; length of femoral neck of 361; platymeric index of 104; robusticity of 251; shaft indices of 254, 265, 268; stature of 236; torsional angles of 243. PATELLAR SURFACE, in achondroplasic femur 443; character of 447; classification of 449; comparative table of height of 425; height of in primates and man 425, 426, 509; measurement of height of 448; in protsimio-human 342; in protsimio-human and dwarf types 434. PATHOLOGICAL BONES 2, 3, Plates XIII—XX, XXIX, XXXIII; study of measurements in 109—111; reversion and 443. PELVIS, orientation of in relation to torsion 136—140. PERISSODACTYLA, pilastric index in 271. PERSIANS, ANCIENT, see Anan femora. PERUVIAN FEMORA, ANCIENT, anomalies in 80, 106; capito-collar length of 361; head of 351; lemotic index of 381; length of neck of 361; torsion of 244. PHOENICIANS, bust ratio in 365; capito-collar length in 361; collar angle in 371; femoral head of 351, 359; head-bust ratio of 354; lemotic index of 381; femoral neck in 361; robusticity of 251; shaft indices of 254, 265; torsional angles of 244. PILASTER, association of with presence of third trochanter 73, 79; in primate femur 482; in primogenial man and apes 459—463, 502; in primogenial and recent man types 341, 462, 463, 469, 476, 477; in protsimio-human 342; source of 108, 263, 329, 332, 459, Plates XXXIII—XXXV, LV, LVII (see also Pilastric index and Frontal pilaster). PILASTRIC INDEX, influence of age on 268, 269; association of with femoral anomalies 79, 101, 102, 104; association of with other characters 462; correlation tables of with other shaft indices 272—275; correlation of with other characters 194, 195, 203, 205—207, 210, 219, 221, 222, 260—268, 282, 283, 300, 301, 507; definition of 9; general discussion of 252—271; mean value of in English 116, 122, 123; for *Pithecanthropus erectus* 13; in primates and man 104, 327—330, 509; in primogenial and recent man 341, 462, 463, 469, 476, 477; in protsimio-human, ape and recent man 343; in protsimio-human and dwarf types 435, 438, 439; racial values of 116, 122, 123, 127, 253, 254; reduced indicial deviations from simio-human for apes and man 492, 493; in sound and paralysed limbs 110; sexual difference in 142, 144, 181, 263; influence of side on 134, 135, 177, 263; standard deviation of in English 163, 189; table of in living forms 270, 271; variability of in English 165; comparative variabilities of 174. PILASTRIC REGION OF SHAFT, in achondroplasic femur 443; correlation of diameters of with other characters 193, 195, 200, 202, 203, 206, 207, 210, 221, 222, 267, 505; cross-section of 255; diameters of 9, 255, 256, Plates I, XXXIII; mean diameters of in English 115, 122; Parsons' measurements on 125; in primates and man 327—330, 509; in primogenial and recent man 468; in protsimio-human, ape and recent man 343; in protsimio-human and dwarf types 434; sexual differences in 145, 147, 182; influence of side on 131, 132, 175; standard deviation of diameters of in English 162; variability in diameters of 164, 169. PINNIPIDEA, pilastric index of 271. PITHECANTHROPUS ERECTUS, Plate XLVI; femoral anomalies in 80, 454; aspalacoid index of 511; band-radial indices of 396—399; bicondylar width and ratio of 390—393; femoral bowing of 279, 282, 283, 317, 318, 460—462; bust ratios of 365, 366; capito-collar length of 361; collar angle of 282, 368, 370; condylar lengths and indices of 17, 405—407, 411—413, 417, 420, 421, 423; distal articulation width and indices of 424—428; distal breadth ratio of 234, 235, 339; Dubois on 451; epiphysial development in 315, 316; epiphysial ratio of 383, 384; evolutionary position of 340, 380, 384, 398, 402, 411, 487, 501, 502; gracility in 455 (see also Shaft indices of); femoral head of 348, 349, 357; head-bust ratio of 354; interspecial differences of types of man and ape from 491, 494, 496, 498; lemotic index of 378, 380; major lengths of 313, 314; Manouvrier's study of 13; midtrochlear angle of 321; femoral neck of 361; obliquity of 239, 240, 282, 319, 320; patellar surface height of 425, 426; pilastric index of 13 (see also Shaft indices of); pithecoid index of 246; popliteal curvature of 11—17, 287; popliteal measurements on 9, 10, 16, 17; popliteal pyramidal index of 307; popliteal skewness of 308, 309, 333; proximal breadth of 346; proximal breadth ratio of 232, 233, 339; reduced indicial deviations from simio-human of 489, 490, 492—500; robusticity of 249, 250; rotular indices of 429, 430; shaft indices of 253, 259, 265, 282, 298, 305, 325, 327, 329, 331, 333, 335, 336; soffit index of 292, 306, 333, 334, 457; stature of 237; indices of taper of 310, 336; torsional angles of 243, 282, 321, 322. PITHECIA, Plates LXXV, LXXVI; aspalacoid index of 511; band-radial indices of 396, 399; bicondylar width and ratio of 390, 393; femoral bowing of 317; bust ratios of 364; capito-collar length in 361; collar angle of 370; condylar lengths and indices of 404, 406, 407, 412, 416, 421; distal articulation width and indices of 424, 426, 427; epiphysial development of 315; epiphysial ratio of 383; femoral head of 348, 357; head-bust ratio of 354; lemotic index of 378; major lengths of 313; midtrochlear angle of 321; femoral neck of 361, 375, 377; obliquity of 319; patellar surface height of 425; pithecoid index of 246; proximal breadth of 346; proximal and distal breadth ratios of 339; robusticity of 250; rotular indices of 429—431; shaft diameters and indices of 325, 328, 331, 333, 336; torsional angles of 322, 323. PITHECOID INDEX, definition of 245; in primates and man 246, 509; in protsimio-human 343; in protsimio-human and dwarf types 435, 437; racial characters of 245—247; reduced indicial deviations from simio-human for man and apes 489. PLATYMERIC INDEX, influence of age on 268, 269; association of with femoral anomalies 79, 103, 104; classification of 8, 9; correlation of with other characters 194, 195, 203, 206, 207, 209, 210, 219, 221, 222, 260—267, 282, 284, 372, 505, 507; correlation tables of with other shaft indices 272—275; definition of 7, Plates VI, VII; discussion of 252—271; mean value of in English and other British series 116, 122, 126; need for standardisation in measurement of 119; unsatisfactory nature of in primate femur 446; in primates and man 325—327, 509; in primogenial and recent man 469, 476, 477; in protsimio-human, ape and recent man 343; in protsimio-human and dwarf types 435, 437, 438; racial values of 104, 127, 128, 253, 254; reduced indicial deviations from simio-human for apes and man 492, 493; sexual difference in 135, 142, 144, 180, 181, 263, 264; influence of side on 134, 135, 177, 178, 263; standard deviation of in English 163, 189; variability of in English 165; comparative variabilities in 174. PLATYMERIC REGION OF SHAFT, Plates I, II, VI, VII, XXXIII; mean diameters of in English 115, 122, 125; measurements on 7; correlation of diameters of with other characters 195, 200, 206, 207, 209, 221; in primate femur 325—327, 509; in primogenial and recent man 468; in protsimio-human, ape and recent man 343; in protsimio-human and dwarf types 434; sexual differences in 145, 147, 182; influence of side on 131, 132, 175; standard deviation of diameters of in English 162; variability of in English 164; comparative variabilities in 169. POIRIER'S FACET, association of in paired bones 77, 78; association of with other femoral anomalies 100, 101, 104; definition of α, β and γ types of 91, 92, Plates VIII—XII; discussion and history of study of 90—104; correlation of with other characters 94—104; in Egyptian femora 93; in prehistoric femora 111; Regnault on 111, 112; sexual percentages of each type on right and left sides in English femora 93. POLES, stature of 238.

Polynesians, femoral anomalies in 80, 106, 108; bust ratios in 365; capito-collar length of 361; collar angle of 371; femoral head of 351, 352, 356, 358—360; head-bust ratio of 354; lemotic index of 381; length of femoral neck of 361; robusticity of 250; shaft indices of 253, 258, 265; stature of 236, 237; torsional angles of 243. Popliteal bicondylar index, see Soffit index. Popliteal curvature, in apes and man 259, 260, 297, 484—487, Plate XXXI; correlation of with other characters 195, 206, 207, 222, 223, 289—296; discussion of 287—297; measure of 13, 14; in *Homo mousteriensis* (*Hauseri*) 15—17; usual and pithecanthropus types of 11—13; in primates and man 332—334; in protsimio-human 342; influence of sex on 288. Popliteal index, influence of age on 268, 269; some comparative values of 16, 17; associated with convexity of popliteal surface 14, 15, 290, 291, 297; correlation of with other characters 194, 195, 203, 206, 207, 219, 222, 263, 264, 284; correlation tables of with other shaft indices 272—275; definition of 13; discussion of 252—269; mean value of in English 116, 124; in primates and man 330—332, 509; in primogenial and recent man 469, 474; in protsimio-human, ape and recent man 343; in protsimio-human and dwarf types 435, 437, 438; racial values of 253, 254; reduced indicial deviations from simio-human in apes and man 492, 493; sexual differences in 135, 142, 144, 180, 181; influence of side on 134, 135, 177; standard deviation of in English 163, 189; variability of in English 165. Popliteal length, correlation of with other characters 195, 206, 222; mean value of in English 115; measurement of 123, Plate I; in primate femur 445; in protsimio-human and dwarf types 434; sexual difference in 51—56, 145, 147, 182; influence of side on 130, 131, 175; standard deviation of in English 162; variability of 164. Popliteal pyramidal index, comparative values of 307; correlation of with popliteal curvature 195, 206, 222, 292—294, 297; definition of 37; in fossil lemuroids 509; mean value of in English 116; in protsimio-human and dwarf types 435, 437, 438; sexual difference in 141, 142, 180, 181; influence of side on 134, 177; standard deviation of in English 163, 189; variability of in English 165. Popliteal region of shaft, correlation of diameters of with other characters 193, 195, 203, 206, 207, 209, 221, 222; curvature of, see Popliteal curvature; mean diameters of in English 115; measurements of 9—17, Plates I—III; Hepburn's measurements on 123; in primates and man 330—334, 509; in primogenial and recent man 468, 479, 484—487; in protsimio-human, ape and recent man 343; in protsimio-human and dwarf types 434, 443; tables of comparative material of 16; types of, Plate XXXII; sexual differences in 145—147, 182; influence of side on 131, 132, 175; standard deviation of diameters of in English 162; variability of in English 164. Popliteal shaft index, correlation of with other characters 300; definition of 39; in fossil lemuroids 509; mean value of for English 116; in protsimio-human and dwarf types 435, 437—439; sexual differences in 141, 142, 181; influence of side on 134, 177; standard deviation of in English 163, 189; variability of in English 165. Portuguese, bicondylar width and ratio of 390, 393; bust ratio of 364; capito-collar length of 361; collar angle of 371; femoral correlations of 505, 506; femoral head of 348, 359; head-bust ratio of 354; lemotic index in 379; femoral neck of 361; obliquity of 239, 240; robusticity of 247, 251; stature of 237; torsion angle of 244. Posture or use, effect of on bones 62, 90, 91, 94, 99, 104—113. Potto, Plates LXIX, LXX. Primary bust ratio, comparative table of 364; correlation of with collar angle 198, 199; definition of 38; mean value of in English 116; in primates and man 363—366, 509; in primogenial and recent man 469, 475, 479; in protsimio-human 385; in protsimio-human and dwarf types 435, 439, 440; reduced indicial deviations from simio-human in apes and man 494, 495; sexual difference in 142, 181; influence of side on 134, 177; standard deviation of in English 163, 188; variabilities of in English 165; comparative variabilities in 171. Primary index of bowing, association of with other characters 462; correlation of with other characters 194, 195, 203, 205—207, 219, 221, 222, 283—286; definition of 36; in foetus 278; of Maori 280; mean value of in English 116; in *Pithecanthropus erectus* 279, 317, etc.; in primates and man 317—319, 509; in primogenial man and apes 460, 461; in primogenial and recent man 469, 474; in protsimio-human, ape and recent man 343; in protsimio-human and dwarf types 435, 437, 438; reduced indicial deviations from simio-human for apes and man 492, 493; sexual difference in 141, 142, 181, 279, 280; influence of side on 134, 177, 281; standard deviation of in English 163; variability of in English 165. Primates, Tables of femoral measurements, Atlas II; aspalacoid index of 511; band-radial indices of 396—399; bicondylar width and ratio of 389—394; bowing of 317—319, 482; bust ratios of 364—366; capito-collar length of 361, 362; collar angle of 369—374; condylar lengths and indices of 403—413, 416—423, 458; distal articulation width and indices of 424—428, 448; epiphysial development in 314—317; epiphysial ratio of 382—385; femur of compared with that of man 311, etc.; Haeckel's pedigree of 480; femoral head of 347—360; interspecial correlations of 372; lemotic index of 378—382; major lengths of 312—314; midtrochlear angle of 320, 321; femoral neck of 361, 374—377; obliquity of 319, 320; patellar surface of 425, 426, 447; pilaster in 482; popliteal apex in 482; proximal breadth of 346, 347; proximal and distal breadth ratios of 338, 339; rotular indices of 428—431; shaft diameters and indices of 325—338; torsional angles of 321—325. Primogenial man, anomalies of femur of 453—464; aspalacoid index of 511; band-radial indices of 396—399; bicondylar width and ratio of 389—394; femoral bowing in 317, 318, 459—461; bust ratios of 364—366; capito-collar length of 361, 362; collar angle of 368—374; condylar lengths and indices of 403, 405—409, 412, 413, 417, 419, 421—423, 458; inadequacy of descriptive memoirs on specimens of 450—452; distal articulation width and indices of 424—428, 448; epiphysial development in 315, 316; epiphysial ratio of 383—385; gracility in 298, 304, 305, 335—337; femoral head of 347—360; in the human pedigree 444—504; lemotic index of 378—382; major lengths of 313, 314; midtrochlear angle of 321; femoral neck of 374—377; obliquity of 319, 320; patellar surface height of 425, 426; pilaster in 460, 461; pithecoid index of 245—247; popliteal curvature in 484—486; popliteal pyramidal index of 307; popliteal skewness of 308, 309, 333; proximal breadth of 346; proximal and distal breadth ratios of 338, 339; robusticity of 249, 250; rotular indices of 428—430, 449; reduced indicial deviations from protsimio-human 489, 490, 492—500; form of shaft in 455—458; shaft diameters and indices of 253—255, 258, 265, 325—338; slenderness in 304; soffit index of 306, 333, 334; indices of taper of 309—311, 336; torsional angles of 241, 322—324. Proboscidea, pilastric index in 271. Propithecus, Plates LXIX, LXX, LXXXII, LXXXIII. Protoneoteric man, definition of 248. Protrusion, platymeric (or lateral), in achondroplasic femur 443; association of with fossa hypotrochanterica 107; in lemuroidea 482; in primogenial man 453, 454; in protsimio-human 342; study of 107, 108, see Plates XXIX, XXXIV—XXXVI, XXXVIII, XXXIX, XLI, XLV, XLIX, LI, LII, LVI, LXV. Protsimio-human, femoral angles of 436; characters of 342—344, 376, 380, 385, 409, 411, 413, 426, 432, 501, 502; comparative table of characters of with dwarf types 434, 435; indices of bust of 439—441; indices of distal epiphysis of 441—444; general indices of 436, 437;

indices of shaft of 437—439. Proximal breadth ratio, definition of 231, 232; evolution of 338; of primates 338, 339, 509; in primogenial and recent man 469, 479; in protsimio-human, ape and recent man 343; in protsimio-human and dwarf types 435, 437; racial values of 233, 339; reduced indicial deviations from protsimio-human in apes and man 489. Proximal epiphysis, breadth of 231, 232; methods of measuring 345; in primates and man 346, 509; in primogenial and recent man types 468, 474, 479; in protsimio-human, ape and recent man 343; in protsimio-human and dwarf types 434. Puma, collar angle of 368.

Quaternary epoch, fossa hypotrochanterica in 67, 68.

Rabbit femora, third trochanter in, Plate XXVII; rotular index of 429. Rachitis, bowing in 278; in English femora 2, Plates XIII, XIV, XXXIII; Hepburn's measurements on femur with 16. Racial dwarfs, Plates XCII, XCIII, see Dwarfs. Racial or evolutionary character, of band-radial index 396—398; of bicondylar width and ratio 389—394; of femoral bowing 460, 461; of bust ratios 363—366; of capito-collar length 361, 362; of collar angle 368—374; of condylar lengths and indices 405—413, 416—423; in correlation 196—202, 264—268; of crural trough 82; of distal articulation width and indices 424—428; of distal breadth ratios 234; of epiphysial ratio 382—385; of gracility 455; in femoral head 347—360; in lemotic index 378—382; of femoral neck 374—377; in obliquity of femur 239, 240; in patellar surface height 425, 426; in pithecoid index 245—247; in popliteal pyramidal index 307; in popliteal skewness 308, 309; in proximal breadth ratio 233; in robusticity of femur 247—252; of rotular indices 428—431; of shaft indices 252—271, 297—311; of soffit index 306, 457; in variability of femur 166—174, 185. Radius, variability in 185. Reduced indicial deviations, definition of 488; from protsimio-human for ape, primogenial and recent man and *Tarsius* 489, 490, 492—500. Reptiles, pilastric index in 270; Retorsion, comparative values of 241, 322; correlation of with torsion of shaft 195, 206, 210, 221; mean value of in English 115; measurement of 30; in primates and man 322—325, 509; in protsimio-human, ape and recent man 343; in protsimio-human and dwarf types 434, 436. Rheumatism, evidence of in English bones 2. Robusticity of head, comparative table of 357—359; mean value of in English 116, 122, 126; measurement of 39; in primates and man 355—360, 509; in primogenial and recent man 469, 475, 479; in protsimio-human, ape and man 385; in protsimio-human and dwarf types 435, 439, 440; racial values of 141; reduced indicial deviations from protsimio-human in apes and man 494, 495; relation of to capital ratio 350; sexual difference in 142, 181; influence of side on 134, 177; standard deviation of in English 163, 189; variability of in English 165. Robusticity of femur, comparative tables of 250, 251; correlation of with other characters 194, 203, 205—207, 212, 218, 219, 284, 303; definition of 38; mean value of in English 116, 122, 126; in primates and man 141, 247—252, 509; in primogenial and recent man 469, 475, 479; in protsimio-human, ape and recent man 343; in protsimio-human and dwarf types 435, 437; reduced indicial deviations from protsimio-human in apes and man 489; sexual difference in 142, 180, 181; influence of side on 134, 135, 177; standard deviation of in English 163, 189; variability of in English 165. Rodentia, aspalacoid index of 511; pilastric index in 271. Romano-British, bicondylar width and ratio of 390, 393; femoral head of 348, 358; popliteal skewness of 308; robusticity of 250; shaft indices of 254, 265; stature of 237. Romano-Gauls, bust ratios in 365; capito-collar length of 361; collar angle of 371; femoral head of 351, 358, 359; head-bust ratio of 354; lemotic index of 381; length of neck of 361; robusticity of 251; shaft indices of 254, 265; stature of 237; torsional angles of 244. Rothwell femora, bicondylar width and ratio of 388, 390, 391, 393; bust ratios in 364; capito-collar length in 361; collar angle in 371; comparison of with English series 124—127; correlations in 197, 198, 200, 215—217; difference between maximum and oblique lengths of 227; head of 49, 50, 348, 352, 358; head-bust ratio 354; lemotic index of 379; length of neck of 361; obliquity of 240; Poirier's facet in 93; robusticity of 247, 251; sexual difference of 49, 50; shaft indices of 254, 265; difference for side of 129; stature from 6, 237; variability in 167, 168. Rotular index, comparative table of 430; definition of 449; in fossil lemuroids 509; and gait 429, 430; in primogenial and recent man 341, 429—431, 448, 449; in protsimio-human and dwarf types 435, 441, 442; reduced indicial deviations from protsimio-human in apes and man 497, 498. Rotular ratio, comparative table of 429; definition of 448, 449; in fossil lemuroids 509; in primogenial and recent man 341, 428, 429, 448, 449; in protsimio-human and dwarf types 435, 441, 442; reduced indicial deviations from protsimio-human for apes and man 497, 498. Round Barrow British, stature of 236. Row-grave Alemanns and Bajuvars, bicondylar width and ratio of 390, 393; collar angle of 371; femoral head of 348, 359; femoral neck of 375; obliquity of 240; pithecoid index of 246; robusticity of 251; shaft indices of 254; stature of 236; torsional angles of 244. Row-grave Swabians, bicondylar width and ratio of 390, 393; collar angle of 371; comparison of with English 127; distal breadth ratio of 234; femoral head of 348, 359; femoral neck of 375; obliquity of 240; pithecoid index of 246; platymeric index of 104; robusticity of 251; shaft indices of 254, 265; stature of 236; torsional angles of 244. Russian femora, anomalies in 88; stature from 238. Ruthenians, stature of 237.

Samoans, stature of 236. Samoyedes, stature of 238. Sandwich Islanders, distal breadth ratio of 234; robusticity of femur in 250. Sardinians, stature of 238. Secondary band-radial index, definition of 399; comparative table of 399; in primates and man 399, 400. Secondary bust ratio, comparative tables of 364, 365; definition of 38; mean value of in English 116; in primates and man 363—366, 509; in primogenial and recent man 469; in protsimio-human 385; in protsimio-human and dwarf types 435, 439, 440; reduced indicial deviation from protsimio-human for apes and man 494, 495; sexual difference in 142, 181; influence of side on 134, 177; standard deviation of in English 163, 188; variability of in English 165. Secondary capital index, see Capital ratio. Secondary index of bowing, 36; definition of 39; in foetus 278; function of 278; mean value of in English 116; in *Pithecanthropus erectus* 279, 317; in primates and man 317—319, 509; in primogenial and recent man and apes 460, 469; in protsimio-human, ape and recent man 343; in protsimio-human and dwarf types 435, 438; sexual difference in 135, 142, 143, 180, 181, 278, 280; influence of side on 134, 135, 177, 178, 281; standard deviation of in English 163; variability of in English 165; in young femora 276—279. Secondary index of neck, association of with Poirier's facet 96—99; comparative table of 377; definition of 37; mean value of in English 116; in primates and man 377, 509; in protsimio-human, ape and man 385; in protsimio-human and dwarf types 435, 439; reduced indicial deviations from protsimio-human in ape and man 494, 495; sexual difference in 141, 142, 181; influence of side on 134, 177; standard deviation of in English 163, 189; variability of in English 165. Semnopithecus, Plates LXXII, LXXIII; aspalacoid index of 511; band-radial indices of

396, 397, 399; bicondylar width and ratio of 390, 393; femoral bowing in 317, 318; bust ratios in 364; capito-collar length in 361; collar angle of 370; condylar lengths and indices of 405, 406, 407, 412, 416, 421, 458; distal articulation width and indices of 424, 426, 427; epiphysial development in 315; epiphysial ratio of 383; femoral head of 348, 349, 357; head-bust ratio of 354; lemotic index of 378; major lengths of 313; midtrochlear angle of 321; femoral neck of 361, 375, 377; obliquity in 319; patellar surface height of 425, 426; pithecoid index of 246; proximal breadth of 346; proximal and distal breadth ratios of 339; robusticity of 250; rotular indices of 429—431; shaft diameters and indices of 325, 328, 331, 333, 336, 337; torsional angles of 322. SESAMOIDS IN MAN, Plates CI A—B. SEX-RATIO, for various characters 144, 145. SEXING OF FEMORA, 40—61, 146, 148; correlations concerning 148—153; regression formula of 153, 154; tables concerning 156—160. SEXUAL DIFFERENCE, in occurrence of femoral anomalies 70, 74, 75, 81—83, 93, 94, 99; examination and discussion of 135—160; in femoral angles 31, 32, 135—140, 239, 240; in femoral bowing 278—280; in femoral correlations 202—211, 217, 219, 267; correlations concerning 148—153; correlation tables concerning 156—160; in femoral lengths 45—47, 51—56, 227; in femoral indices 37, 141—144, 263; in absolute size 145—160; in size of articular surfaces 41, 53—56; in orientation of pelvis 136—140; in popliteal curvature 288; in relative length of neck 379, 380, 382; in variabilities 169—173, 179—184. SHAFT OF FEMUR, axis of 19—21, 24, 29; correlation of length of with other characters 194, 195, 202, 203, 206, 207, 210, 212, 213, 218—222, 266, 267; indices of 38; mean length of in English 115; measurement of length of 20, Plate I; in fossil lemuroids 509; obliquity of 29—31; in primogenial and recent man 455—458, 468, 474; in protsimio-human, ape and recent man 343; in protsimio-human and dwarf types 434; sex-ratio for length of 144; sexual difference in 145—147, 182; influence of side on length of 130, 131, 175; standard deviation of length of in English 162; variability in length of in English 164. SHETLAND FEMORA, pilastric index of 256. SIAMESE, stature of 238. SICILIANS, stature of 238. SIDE OF FEMUR, and femoral anomalies 74, 77, 78, 93; differences associated with 128—135, 217, 263; influence of on bowing 281; influence of on correlation 202—204, 219, 266; influence of on obliquity 239, 240; influence of on popliteal curvature 288; variability of 174—179. SIKHS, stature of 236. SIMIADAE, aspalacoid index of 511, 512; band-radial indices of 396, 397, 399; bicondylar width and ratio of 389, 390, 392—394; femoral bowing in 317—319, 482; bust ratios in 364—366; capito-collar length in 361, 362; collar angle of 369, 370; condylar lengths and indices of 403, 404, 406—408, 412, 413, 416, 419, 421—423, 458; distal articulation width and indices 424—428; evolutionary position of 340, 341, 480, 482; epiphysial development in 315, 316; epiphysial ratio of 383, 384; femoral head of 348, 349, 355—357; head-bust ratio of 353—355; lemotic index of 378—380; major lengths of 313, 314; midtrochlear angle of 320, 321; femoral neck of 361, 374—377; obliquity of 319, 320; patellar surface height in 425, 426; pilaster in 271, 482 (see also Shaft indices); pithecoid index of 245—247; apex of popliteal surface in 482; proximal breadth of 346, 347; proximal and distal breadth ratios of 338, 339; robusticity of 249, 250; rotular indices of 428—431; shaft diameters and indices of 325—337; torsional angles of 322—324. SIMIINAE, see Anthropoid apes. SIMIO-HUMAN FEMUR = Protsimio-human, which see; character of 501—504; definition of 488; reduced indicial deviations from in apes and man 489, 490, 492—500. SIZE, and ancestry of man, Plates LXIII, LXIV, 487, 488. SKULL, variability of measurements on 186—191. SLAVS, ANCIENT, bust ratios of 365; capito-collar length of 371; collar angle of 371; femoral head of 351, 358, 359; head-bust ratio of 354; lemotic index of 381; length of femoral neck of 361; robusticity of 251; shaft indices of 254, 265; stature of 237; torsion angle of 244. SOFFIT INDEX, comparative values of 306; correlation of with convexity of popliteal area 195, 292, 293, 297; definition of 36, 37; in fossil lemuroids 509; mean value of in English 116, 123; in primates and man 332—334; in primogenial and recent man 341, 457, 469, 474; in protsimio-human, ape and recent man 343; in protsimio-human and dwarf types 435, 437, 438; reduced indicial deviations from protsimio-human in apes and man 492, 493; sexual difference in 141, 142, 144, 181; influence of side on 134, 177; standard deviation of in English 163, 189; variability of in English 165. SPY FEMUR, Plates XLVIII—LIV; anomalies in 453, 454; aspalacoid index of 511; band-radial indices of 396, 399; bicondylar width and ratio of 390, 391, 393; bowing of 460; bust ratios of 365; collar angle of 370; condylar lengths and indices of 17, 405, 407, 412, 417, 421; distal breadth ratio of 234; epiphysial ratio of 383; gracility in 455; head of 348, 351, 358; head-bust ratio of 354; Klaatsch on 452; lemotic index of 378; neck of 375, 377; obliquity of 240; pilaster in 460; popliteal curvature in 484, 485; popliteal pyramidal index of 307; popliteal skewness of 308; proximal breadth ratio of 233; shaft indices of 253, 258, 265, 298, 305; soffit index of 306, 457; stature from 238; indices of taper of 309, 310; torsion of 241, 243. STANDARD DEVIATION, of measurements of English femora 162; of indices of English femora 163; racial differences in 166—174; differences of with side 174—179; sexual difference in 179—184. STANDARD HORIZONTAL PLANE OF FEMUR, 24, Plates I—III. STANDARD VERTICAL PLANE OF FEMUR, 23, Plate I. STANDARDISATION OF MEASUREMENTS, need of 28, 114, 117—119, 128, 360, 363, 366—368, 374, 378—382, 388, 414, 446, 450. STATURE, correlation of with shaft indices 267, 268; of English 6; racial table of 236—238; reconstruction of 5; of protsimio-human 342. STONE AGE, femoral anomalies in 67, 68, 70, 75. STRUTHIONIDAE, pilastric index in 270. SYPHILIS, evidence of in English bones 2, Plates XVII—XX. SWAN HILL AUSTRALIAN, Hepburn's popliteal measurements on 16, 17. SWISS ALEMANNS' FEMORA, bicondylar width and ratio of 390, 393; collar angle of 371; distal breadth ratio of 234; obliquity of 239, 240; shaft indices of 254, 262, 263, 265; stature from 236; torsion of 244. SWISS FEMORA, MODERN, bicondylar width and ratio of 390, 391, 393; comparison of with English 127; collar angle of 371; distal breadth ratio of 234; obliquity of 240; pithecoid index of 246; robusticity of 247, 251; shaft indices of 254; torsion of 244.

TABLES, concerned with femoral anomalies 67, 68, 74—83, 88, 89, 93—103, 108; comparative values of aspalacoid index 511; of band-radial indices 396, 399; of bicondylar width and ratio 390, 393; of indices of bowing 317, 460; of bust ratios 364, 365; of capital indices and vertical diameter of head 348, 351; of capito-collar length and length of femoral neck 361; of collar angle 370, 371; of lengths of condyles 404, 405; of condylar lengths index 406, 407; of condylar indices 412; of condylar ratios 416, 417; of condylar obliquity indices 421; of distal articulation width 424; of distal articulation ratio 426; of distal articulation index 427; of distal breadth ratio 234; of epiphysial development 315; of epiphysial ratio 383; of indices of gracility and taper 298, 305, 310, 336; of robusticity and ellipticity of head 357—359; of head-bust ratio 354; of lemotic index 378, 381; of major femoral lengths 313; of midtrochlear angle 321; of indices of neck 375, 377; of obliquity of femur

240, 319; of patellar surface height 425; of pilastric diameters and index and indices of slenderness 253, 254, 328; of pithecoid index 246; of platymeric diameters and index 253, 254, 325; of popliteal diameters and index 253, 254, 331; of popliteal pyramidal index 307; of popliteal skewness 308, 333; of primate femoral characters, Atlas, Part II, folding sheets; of proximal breadth 346; of proximal and distal breadth ratios 233, 339; of robusticity of femur 250, 251; of rotular indices 429, 430; of soffit index 306, 333; of stature 236—238; of torsional angles 243, 244, 322; of femoral characters and indices—for English 115, 116; for fossil lemuroids 509; for primogenial and recent man 341; for protsimio-human 343, 385, 432; for protsimio-human and dwarf types 434, 435, 438, 439, 441; for Cromagnon and Grimaldi types compared with recent white and recent negro races 468, 469, 474; for Neanderthal, Galley Hill, Cromagnon and Recent Man types 479; correlation, and correlation coefficients—for English femora 194, 195; (individual English femora) sheets I—XIII of Atlas, Part I; concerning sexual characters or appreciation of sex 149, 152, 156—160, 206, 207; for shaft indices 272—275; for popliteal curvature with other characters 289—296; for parts of bust with maximum length, etc. 213; of difference in for right and left femora 203; racial values of 197, 200, 505, 507; for comparison of methods of determining correlation 193; of reduced indicial deviations from simio-human in apes and man 489, 492, 494, 497, 499; of interspecial differences for man and apes from *Pithecanthropus*, Neanderthal and Recent Man 491, 494, 498; for comparison of mean index with index of means 121; comparing English femora with other British series 122, 123, 126; showing effect of side on characters and indices of femur 129, 131, 134, 175—177; showing influence of sex on characters and indices of femur 46, 47, 136, 142, 145, 147, 179, 181, 182; concerning methods of sexing femora 54—57, 60; of standard deviation of characters for English femora 162, 163; of coefficients of variation for English femora 164, 165. TARSIUS SPECTRUM, Plates LXIX, LXX; aspalacoid index of 511; and ancestry of man 501, 504; band-radial indices of 396, 399; bicondylar width and ratio of 390, 393; femoral bowing of 317, 318; bust ratios of 364; capito-collar length in 361; collar angle of 370; condylar lengths and indices of 404, 406, 407, 412, 416, 421; distal articulation width and indices of 424, 426—428; epiphysial development of 315; epiphysial ratio of 383; femoral head of 348, 357, 360; head-bust ratio of 353, 354; lemotic index of 378, 380; interspecial differences of from types of man and apes 491, 494, 496, 498; major lengths of 313, 314; midtrochlear angle of 321; femoral neck of 361, 375—377; obliquity of 319; patellar surface height of 425; pithecoid index of 246; proximal breadth of 346; proximal and distal breadth ratios of 339; reduced indicial deviations from simio-human 489, 490, 492—500; robusticity of 250; rotular indices of 429, 430, 448, 449; shaft diameters and indices of 325, 327, 328, 330, 331, 333, 336, 337; torsional angles of 322. TETRAPROTHOMO, condylar lengths and indices of 405, 407, 410—413. THIRD TROCHANTER, Plates XXVII—XXIX, XXXV, XXXVIII, XL, LVII; history of study of in man and animals 63—80; association of with other anomalies 67, 75, 83, 89, 100, 101; association of with muscularity 62, 65, 68, 70—73; association of with pilaster 73, 79; association of with popliteal curvature 296; in achondroplasic femur 443; and descent of man 483; in fossil lemuroids 510; in primogenial man 453; in protsimio-human 342. TIBIA, variability in 185. TIGRESS, collar angle of 368. TILBURY MAN, Plates LV—LVII; anomalies in femur of 454; bowing of 460; gracility of 455; Owen on 451; pilaster of 460; popliteal curvature of 484, 485; popliteal skewness of 308; shaft indices of 253, 298, 305; stature of 238; indices of taper of 310. TODAS, stature of 236. TORSIOMETER 30, Plate XXI. TORSIONAL ANGLE, see Plates IV, V; correlation of with other characters 194, 195, 203, 206, 207, 210, 212, 216, 219, 220, 282, 286, 505, 507, 508; mean value of in English 115; measurement of 23—29; for primate femur 321—325, 509; in primogenial and recent man 468, 474, 476, 479; in protsimio-human, ape and recent man 343; in protsimio-human and dwarf types 434, 436; racial character of 127, 128, 239—244; in relation to orientation of pelvis 136—140; sexual difference in 136, 147, 179, 180; influence of side on 131—133, 176, 217; standard deviation of in English 162, 190; variability of in English 164, 190, 241; comparative variabilities in 171. TORSION OF SHAFT, comparative values of 241, 322; correlation of with other characters 195, 203, 205—207, 210, 221, 222, 285; mean value of in English 115; measurement of 25, 27, 28, 30, Plate XXI; in primates and man 322—325, 509; in protsimio-human, ape and recent man 343; in protsimio-human and dwarf types 434, 436; sexual difference in 136—140, 147, 179, 180; influence of side on 131, 132, 176; standard deviation of in English 162, 190; variability of in English 164, 190, 241. TRANSVERSAL RATIOS, see Index of gracility. TREPSIMETER, JOB'S 25. TROCHANTERIC LENGTH, comparative values of 313; correlation of with other characters 194, 205—207, 210, 227; difference between oblique trochanteric length and 228; mean value of in English 115; measurement of 4, Plate I; in primates 312—314, 509; in primogenial and recent man 468, 474; in protsimio-human, ape and recent man 343; in protsimio-human and dwarf types 434; sexual difference in 145, 147, 182; standard deviation of in English 162; symmetry in 130, 131, 133, 175; variability of in English 164; comparative variability of 167. TROCHANTERIC LENGTH, MAXIMUM, correlation of with oblique trochanteric length 194, 205, 206, 212; mean value of in English 115; measurement of 4, Plate I; effect of paralysis on 109; in primogenial and recent man 468; in protsimio-human, ape and recent man 343; in protsimio-human and dwarf types 434; on sexual character 54, 55, 145, 147, 182; influence of side on 130, 131, 133, 175; standard deviation of in English 162; variability of in English 164. TROCHANTERIC OBLIQUE LENGTH, correlation of with other characters 194, 205, 206, 212, 227; mean value of in English 115; measurement of 7, Plate I; effect of paralysis on 109; in primogenial and recent man 468; in protsimio-human, ape and recent man 343; in protsimio-human and dwarf types 434; sexual difference in 51, 52, 54—56, 145—147, 182; influence of side on 130, 131, 133, 175; standard deviation of in English 162; variability of in English 164. TROPOMETER, BROCA'S 25, 29. TUBER SUPRACONDYLOIDEUM, Plate XXVI; associated with third trochanter 89; discussion of 85—90; sexual percentages of in various races 88. TUBERCLE, GASTROCNEMIC, Plates XXII, XXIII, XXX; association of in paired bones 78. TUPAIA, Plates C A—B; aspalacoid index of 511, 512. TURKS, bust ratios of 365; capito-collar length of 361; collar angle of 371; femoral head of 351, 358; head-bust ratio of 354; lemotic index of 381; length of femoral neck of 361; robusticity of 251; stature of 238; torsion angle of 244. TURTLES, pilastric index in 270.

ULNA, variability in 185. UPRIGHTNESS, and band-radial index 398, 443; and obliquity of lateral condyle 424; and rotular index 429, 430; and femoral torsion 241. URSUS AMERICANUS, condylar lengths index in 407, 410.

VARIABILITY OF FEMORA, 161—191; comparison of in English with that of other races 166—174; comparison of with that of other bones 184—191; influence of sex on 179—184; influence of side on 174—179. VEDDAHS, bust ratios

of 365; capito-collar length of 361; collar angle of 368, 371; condylar ratios of 417, 419; distal breadth ratio of 234; epiphysial ratio of 383; femoral head of 351, 352, 356, 359; head-bust ratio of 353, 354; lemotic index of 381; length of femoral neck of 361; proximal breadth ratio of 233; robusticity of 250, 251; shaft indices of 253, 265, 268; stature of 237, 238; torsion angle of 244. VENEZUELIANS, ANCIENT, capito-collar length of 361; size of femoral head of 351; lemotic index of 381; length of femoral neck of 361. VIENNESE FEMORA, collar angle of 371; Mikulicz' measurements on 230, 231; obliquity of 240; torsion of 244. VITI ISLANDERS, bicondylar width and ratio of 390, 392, 393; collar angle of 370; distal breadth ratio of 234; proximal breadth of 347; proximal breadth ratio of 233.

WEIGHT OF FEMORA, effect of paralysis on 109. WHITECHAPEL FEMORA, compared with Liverpool Street Series 2. WILBRAND'S PROCESS, Plates XXIII—XXV, XXVII, XXXVIII; in Barbary Ape, Plate LXVII; description of 83—86.

YOUNG BONES, asymmetry in length of 129; bowing in 276—279, 281, 306; collar angle of 110, 111; gracility of 303—305; lemotic index of 381; neck indices of 375, 376; popliteal diameters of 12; shaft indices of 268, 269; slenderness of 304.

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